ELEMENTS

OF

GEOLOGY

AND

PHYSICAL GEOGRAPHY,

ILLUSTRATIVE OF THE PAST AND PRESENT
CONDITION OF THE GLOBE.

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PREFACE.

The object of this elementary treatise is to exhibit the facts of Geology arranged in as concise and systematic a form as the present progress of the science will admit, while all theoretical discussions are avoided, or only alluded to in so far as they serve to elucidate actual phenomena.

The first portion treats of the nature of the mineral substances and rocks, which enter into the composition of the earth's strata, the key to all accurate geological knowledge; then follows an account of the animal and vegetable remains, which characterize a great proportion of the strata; and the concluding part embraces a view of the past and present condition of the earth's surface, including the subjects of climate, temperature, and volcanic action.

But Geology is one of those sciences which cannot be learnt by books alone, or studied in the closet. All that has been attempted here, then, is a class book to aid verbal instruction, and the actual inspection of nature.

PREFACE.

This treatise forms the first of a series on natural science, intended as elementary works to the general student, but more especially to meet the views of the comprehensive system of early education now generally pursued.

From considerable practical experience, the author is convinced that the facts of Geology, as well as those of the other departments of natural history, can be as readily comprehended, and are as eagerly appreciated, at the age of twelve or fourteen, as at twenty or twenty-five. By beginning pupils at an early age with these studies—which may be accomplished without in the smallest degree infringing on other elementary labours — it renders them acquainted with scientific terms, and trains their minds to habits of attention to oral communications, which will greatly facilitate their more mature acquisitions. It is but too well known, that for want of this preliminary knowledge and these habits, the first year of a University attendance is almost spent in the attainment of the mere alphabet of science.

With these views, neither the language nor the facts of this work have been too much simplified — so that what is learnt by the young pupil may stand as so much of preparatory training, while the minute details (which, in some instances, may be passed over at the discretion of the teacher) will, it is hoped, be found ample and accurate information to the general and more advanced student.

A Glossary of strictly geological terms is subjoined, with a series of questions on the different sections, which may be of use to the teacher, while they will also serve the purpose of an index to the whole.

A Geological Map of England and Scotland forms the Frontispiece. The boundaries of the different formations are marked in outline, and directions are given at the side

with reference to numbers, by which the map may easily be coloured, and thus the localities of strata will be more accurately impressed upon the memory.

A list of the most useful works on Geology is also subjoined, many of which have been consulted in the composition of this treatise. It was deemed more advisable to refer to them thus generally, than to cumber the pages with frequent notes and quotations, which only tend to embarrass the student just entering on the subject.

To this edition has been added several new woodcuts of organic remains, and a synopsis of Mineralogy, including all the species of minerals most usually met with, arranged according to the most approved system.

A few directions have also been given for the prosecution of practical Geology,—a department of the science which, both for its utility, and the instruction and amusement which it affords, cannot be too strongly recommended to the student.

21, Forth Street, 1839.

CONTENTS.

GEOLOGY.

SECTION I.

FIGURE AND DENSITY OF THE EARTH.

1. Geology embraces a history of the various strata composing the superficial crust of the globe, and the successive changes which these have undergone : Mineralogy treats of the simple substances which enter into the composition of the earth's strata.

2. The greatest depth to which man has penetrated into the earth does not much exceed 2700 feet, and the highest mountains extend only to 29,000 feet, or about five miles ; whereas the distance from the centre of the earth to its surface, or half the diameter, is 3955 miles. The depth of the surface, then, which comes within the view of man, is extremely small compared to the vast profundity of our sphere.

3. Various conjectures have been formed regarding the density of the interior of the earth. By the experiments of Playfair and Maskelyne, the mean density has been estimated as five times greater than that of water, and, consequently, that the specific gravity of the globe as a mass is about double the weight of the materials forming the surface. Laplace estimated the mean density as only one-half greater than that of the surface. It is probable, then, that the density of the earth gradually increases from the surface towards the centre.

4. The external form of the earth is not exactly circular ; it is a spheroid, being flattened somewhat at the poles, and elevated at the equator. This elevation at the equator is about twenty-six miles.

This form of the earth is exactly that which a revolving body would have assumed had it been originally in a fluid state, or had the particles of which it is composed been of any other condition than that of a solid. We can form no conception of the original condition of the matter of the globe, because we now see it after it has undergone many chemical changes and combinations.

5. The surface of the earth, as we now behold it, is divided into mountains and valleys. These are intersected by lakes and rivers, and the ocean covers nearly three-fourths of the whole.

The position of mountains, and the distribution of land and water, might, on a superficial view, appear to be made with great irregularity ; yet we shall find that admirable design and forethought have fitly planned and portioned out the whole. A glance at a map of the globe will shew that the greatest proportion of dry land is in the northern hemisphere ; that immense oceans on all sides surround the continents, and join together to encircle the globe. The mean depth of this ocean has been calculated at from two to three miles ; so that it is in fact only the mountain ranges and most elevated portions of the crust of the globe, that, standing out from this immense circumference of waters, constitutes the habitable land.

6. The earth also is surrounded by a circle of air called the atmosphere. This sphere is conjectured to extend to the height of from 45 to 50 miles, and is the medium by which vapour and heat are diffused over the globe.

Though this atmosphere appears of vast extent, yet, as compared to the mass of the globe, it is extremely limited, only amounting to about one 1-80th part of the half of the earth's diameter.

The air being a highly elastic fluid, those portions of it which are nearest to the earth have a much greater density than the higher strata, so that the higher we ascend from the earth's surface, the air becomes lighter.

SECTION II.

SIMPLE SUBSTANCES COMPOSING THE CRUST OF THE GLOBE.

7. ALTHOUGH the various strata composing the earth's surface present considerable diversity of appearance, yet they are formed of a very small number of simple substances; and it is by the combination of these in certain proportions that the varieties of mineral bodies are produced. The simple earths which enter into the composition of rocks, and which are found to prevail in the greatest abundance in nature, are silica, alumina, lime, and magnesia. The earths found more sparingly diffused, are baryta, strontia, yttria, zirconia, and glucina. To these are to be added the two alkalies, potassa and soda, which are also found in considerable quantities, and the various metals, with carbon and sulphur.

8. But substances on the earth's surface are rarely seen in their original simple state, or as they can be obtained by the analysis of the chemist. In fact, we only see them after they have undergone a series of changes and chemical combinations. Thus, oxygen, one of the ingredients of the atmosphere, enters largely into combination with the substances above mentioned; and though, in its simple state, a light and invisible gas, becomes consolidated in the earths and metals, and forms sometimes one-half and one-third of the solid contents of rocks and minerals. Oxygen and nitrogen compose the principal part of the atmosphere; and oxygen and hydrogen constitute water, a universally and largely diffused fluid.

9. SILICA, or QUARTZ, is seen in nearly a pure state, in rock crystal, flint, agate, chalcedony, and in the siliceous sand of the sea shore. It is white, tasteless, and inodorous, and so hard, that it cannot be scratched with steel; but on the contrary it scratches glass, and most other minerals. It is found in masses, in veins, and in crystals. Its fracture is conchoidal, and it cleaves or separates into plates with great difficulty. Its most usual crystalline form, is that of a prism with six sides, terminated by a six-sided pyramid; but its primitive form is a rhomboid. It is usually colourless, as in transparent rock crystal, or white as in quartz rock: but it is also frequently coloured by an admixture of other substances, of a red, purple, brown, or black hue.

10. Silica requires an intense heat for its fusion—is insoluble in water, and in all the acids except the fluoric. It combines readily, however, with potassa and soda by fusion; and if the alkali greatly predominate, this compound may be easily dissolved in water. If to this solution a little acid be added, the silica is precipitated in a fine powder, which also is, to a certain extent, soluble in water. In this manner may be accounted for the existence of silica in mineral springs, as the geysers, or boiling fountains of Iceland, and the formation of chalcedony, which evidently has been produced by the consolidation of a fluid dropping from the roof to the bottom of hollow cavities. This also explains the circumstance of vegetable and animal remains being sometimes found within a quartz crystal, with their structures perfectly preserved.

11. Silica is one of the most abundant of all earths, and besides existing in a pure or nearly pure state, as rock crystal, chalcedony, flint, agate, and opal, it enters into combination with many of the other earths, forming rocky masses, and minerals, and precious gems, as the garnet, amethyst, and many others. Silica is found in some vegetable productions, as the stalks of reeds and the different kinds of grains. It forms the outer coating of the bamboo, which will strike fire with steel, and the substance called tabasheer is composed of this mineral. A mixture of silica and soda forms glass; of silica and alumina the various kinds of china ware and pottery are made.

Silica is a compound of a simple substance called silicon, supposed to be of the nature of an acid, and of oxygen gas.

12. Alumina, or clay earth, is seldom found pure in nature, but in combination with other substances is extremely abundant. Clayey substances, when breathed upon, exhale a peculiar earthy odour, which is a distinctive mark of alumina. When perfectly pure, it is of a white colour. It is insoluble in water, although it seems to have a strong attraction for it, and, as usually obtained, contains half its bulk of this fluid. In fine powder it forms a transparent gelatinous mass with water. It readily unites with acids, forming with the sulphuric the well known substance alum. Alumina does not suffer any change from the strong heat of a common furnace, except that it contracts in volume, probably by its parting with the water which it contains; but with a more intense heat, it melts into a semi-transparent globule.

13. Alumina enters largely into the composition of rocks, and

its most usual form is that of felspar, which is a compound of silex and alumina, with a portion of potassa, lime, and oxide of iron. Felspar is found of various degrees of hardness and colour. It is sometimes white and crystallized, in the form of four and six-sided prisms, flattened at the extremities; or cream coloured, passing into light and dark red, according to the quantity of oxide of iron which it contains. It is inferior to quartz in hardness, but scratches glass.

14. FELSPAR is a very abundant mineral: from its containing a large proportion of alumina it is employed in the manufacture of pottery ware. The finest material of this kind is the Chinese felspar, called *petuntz.* Cornwall supplies the greatest proportion of that used in the English manufactories. Felspar composes a great part of the Pentland Hills, but it is too much tinged with iron ore to be useful in the arts. The Labrador felspar is a beautiful mineral, reflecting a variety of hues, according to its position to the rays of light.

15. Alumina, in its purest form, and crystallized, is the chief ingredient of some of our most beautiful gems, as the topaz, and other varieties of the sapphire.

Alumina is supposed in its simple and primary state to be a metallic body. As it is usually seen, it is a compound of the metal aluminum, and oxygen.

16. LIME is a very prevalent ingredient in rocks, and, combined with carbonic acid, forms marble, chalk, and limestone, of various degrees of hardness. The purest carbonate of lime is found in calcareous spar, whose crystals assume a variety of forms, all, however, resulting from a primary rhomboid. It also exists in great purity in Carrara marble, used in statuary. This rock, from the structure of its close compacted crystals resembling sugar, has been called saccharine marble. When subjected to heat, carbonate of lime loses its carbonic acid, and becomes caustic lime, which has a hot pungent taste. In this state it can be sparingly dissolved in water. If lime be subjected to an intense heat, it fuses into a transparent glass. When heated under great pressure, it melts, but retains its carbonic acid.

17. All minerals composed of lime are readily distinguished from quartz, by their being so soft as to be easily scratched with a knife. The carbonates of lime are known also by the effervescence or escape of carbonic acid gas, which takes place when any acid, as the muriatic, is dropt on them.

Lime is readily dissolved in almost all the acids.

18. Lime enters largely into the composition of animal bodies, forming the solid part of the bones and teeth, and the shells of many mollusca. It is also extensively used in agriculture, and enters into the composition of vegetables. It is diffused in the ocean, in the form of muriate of lime, and exists in many springs.

A metallic base, called calcium and oxygen, form the constituents of lime.

19. MAGNESIA is a white-looking light earth, somewhat similar to lime, and enters into the composition of several minerals, although it is not by any means so extensively diffused as the other earths which have been enumerated. Most minerals containing magnesia have a greenish appearance and soapy feel, such as asbestos, talc, soap stone. Combined with lime, it forms beds of magnesian limestone. It usually exists as a carbonate, is insoluble in water, but readily dissolves in an acid. It is found in considerable quantity as a muriate of magnesia in sea water, but does not enter into the composition of animals or plants. It is supposed to have a metallic base combined with oxygen.

20. The other earths mentioned, Baryta, Strontia, Glucina, Yttria, are not of importance in a geological point of view, as they rarely enter into combination with rocky masses, but are found in veins and beds, usually crystallized. Baryta is characterized by its great weight. Both it and strontia are of a poisonous nature, and are soluble in the acids.

21. POTASSA and SODA.—These salts, called mineral alkalies, also exist in combination with the earths forming rocks, giving softness and friability to granite, and a peculiar character to basalt.

Potassa enters largely into the composition of vegetable and animal bodies. Soda exists in considerable abundance in the water of the ocean, in marine vegetables, in salt springs, and in combination with muriatic acid in extensive beds of rock salt.

Potassium and sodium, the metallic bases of these alkalies, are easily procured, and have such a strong affinity for oxygen, that they will combine with this substance under whatever modifications it is to be found, and with such rapidity as to cause violent heat and flame. When a piece of metallic potassium is thrown on water, it immediately bursts into a vivid flame, and, absorbing the oxygen of the water, is converted into common potassa.

22. MICA.—This white, glittering, silvery looking substance, is found plentifully in granite : it is a compound of alumina, silica, magnesia, and oxide of iron. It is of a lamellar texture, and

is easily split into thin, flexible, elastic, and transparent plates. These plates, before the invention of glass, were used as window panes, and in some remote parts of Russia are still employed for this purpose. They are also, from their extreme thinness and transparency, employed to enclose minute objects for the microscope. Mica is so soft as to be easily scratched with the nail. Its usual colours are gray, brown, and sometimes black; occasionally it is found crystallized in four and six-sided prisms. It is distinguished from talc, a substance very similar, by being flexible or easily bent, while the latter is brittle and inflexible.

23. Hornblende.—This, also, is a compound of alumina, silica, magnesia, and black oxide of iron. This latter substance tinges hornblende of a deep green, gray, and black colour. Hornblende is a prevalent ingredient in all the trap rocks, alternating with augite, a green coloured mineral of similar composition. It is found massive, or more generally formed into prismatic crystals.

SECTION III.

GENERAL ARRANGEMENT OF STRATA.

24. On examining the solid crust of the earth, we find, in the first place, the soil, which is composed of loose particles of rocks reduced to fine dust, and mixed with the decayed parts of vegetables and animals; then beneath this is found clay, sand, or gravel, either in separate layers, or mingled together; and last of all we come to hard rock, placed in layers one above the other, and these prevail to the greatest depths to which man has penetrated.

These layers of rocks differ from each other, not only in the nature of the ingredients of which they are composed, but in the manner in which they have been formed, some rocks having a uniform crystalline structure, and others being composed of the fragments of older rocks firmly compacted together. Mingled with the newer rocks, too, are found the remains of plants and animals converted into petrifactions, while in the older rocks there are no traces of such remains.

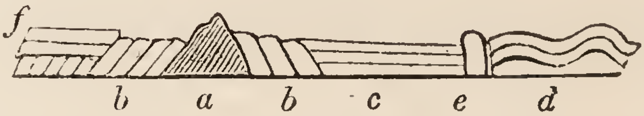
25. The first division of rocks, then, is into—*Primary*, containing no organic remains of plants or animals; and, *Secondary*, or those rocks in which such remains are found.

26. Many kinds of rocks are disposed in layers one above the other, called strata, while others, again, are in masses, without any appearance of such an arrangement. Hence another division of rocks into *Stratified* and *Unstratified.*

27. The unstratified rocks are those which have been formed by intense heat in the interior of the earth's crust, and thrown upwards in masses more or less of a crystalline character, as granite, greenstone, lava. Hence they are called igneous or plutonic rocks.

28. The stratified rocks are those which have been formed of the worn down fragments and minute particles of igneous rocks; which particles having been deposited from a temporary suspension in water, the term *sedimentary* has been used as characteristic of this class.

No. 1.

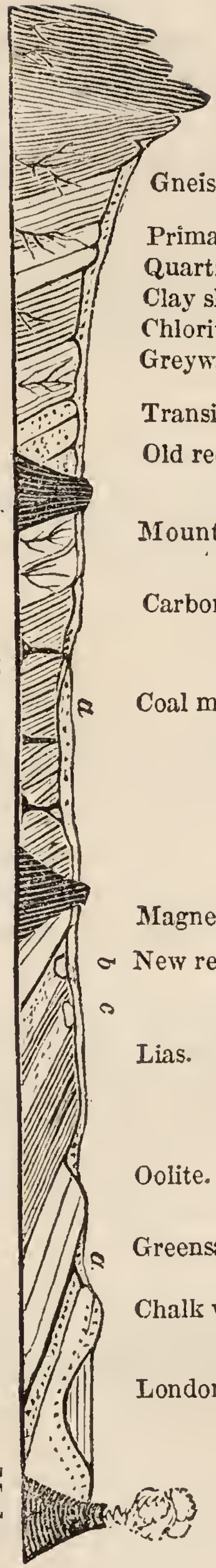


The various forms of stratification are exemplified by the section, thus :—*a* is a mass of unstratified rock ; *b b* are layers of stratified rocks inclined upon each side of this mass; *c* represents horizontal strata ; *d* waved strata ; *e* a perpendicular slip or fault ; *f* horizontal strata placed above inclined, in which case the two are said to be unconformable to each other. The dip of the strata is the angle which they make with a horizontal line, and the dip is said to be east and west, or any other point according to the position of the strata.

We have, then, the igneous or plutonic rocks unstratified, as granite, greenstone, lava. The sedimentary rocks stratified, as slates, sandstones, limestones.

29. There is a certain position in which these rocks and strata are found to be arranged in their natural state, which points out the successive periods when they have been formed or deposited; and which may be exemplified by the following diagram or section. This section is supposed to comprehend a view of a range of country extending from the Grampian Mountains in Scotland, through the middle of England, and across the Channel to Paris, and the volcanic regions of Italy. A section is intended to represent the strata, seen as if a straight line were cut through the whole extent of Britain, in the middle, exposing a side view of the rocks laid one upon another in the manner here shewn.

No. 2.



GENERAL SECTION OF STRATA.

a a a Alluvium and superficial soil. — *v v v* Metallic veins. — *b c* Rock salt and gypsum.

Now, this view of the successive strata of a portion of country, affords an example of the position of rocks generally on the earth's surface. There is not always, it is true, the same unvaried succession: in some countries, certain strata may be altogether wanting, and one or two kinds of rocks may prevail in particular districts to the exclusion of others; yet, where the stratified rocks exist, they will be found to succeed each other in the order of the section, so that a table may be thus formed of all the rocks entering into the composition of the earth's surface.

IGNEOUS OR PLUTONIC ROCKS.

Granite, Greenstone, Porphyry, Lava,	Unstratified—of different ages—more or less crystalline—destitute of organic remains.

SEDIMENTARY ROCKS.

Gneiss, Mica slate, Clay slate, Chlorite slate, Quartz rock, Primary marble,	Stratified—primary series—containing no organic remains.
Graywacke, Transition limestone, Old red sandstone, Mountain or carboniferous limestone, Carboniferous sandstone, Magnesian limestone, New red sandstone, Lias, Oolite, Greensand, Chalk,	Secondary series—stratified—containing remains of plants and animals, for the most part extinct species.
London clay, Paris strata, &c. Diluvium, Alluvium, Present soil,	Tertiary series, or supra-cretaceous strata, containing the remains of marine animals, quadrupeds, birds.

SECTION IV.

IGNEOUS OR PLUTONIC ROCKS.

30. Granite.*—This rock occurs in masses, often continuous and of immense extent, occupying the lowest position in the earth's strata, over which the other rocks are situated. Sometimes it occurs in large oblong or cubical masses, half separated by fissures into irregular beds, and in this way it has been mistaken for a stratified rock. Occasionally these masses put on the shape of irregular spheroids, but such appearances are most likely caused by the effects of the atmosphere partially wearing fissures in the mass, and rounding their angles. True granite, under all its modifications, is an unstratified rock.

31. The substances which enter into the composition of granite are quartz, felspar, mica, and hornblende. Most commonly granite is composed of the three first ingredients; occasionally all the four enter into its composition; but there are granites where only two of these substances are present.

Granite is a crystalline aggregate, the substances composing it being confusedly mixed or compacted together, the several crystals interfering with each other at all points, and evidently exhibiting the appearance of a simultaneous formation.

It varies much in the proportions of its constituent parts, as also in their size. In general the felspar predominates, and the mica is in smallest proportion. Most commonly the ingredients are of a minute granular form, regularly mingled together. At other times they are of a larger grain. Sometimes the masses of quartz and felspar are from one to two or three inches in size, and the corresponding lamina of mica of equal or greater magnitude. Masses of fine and large grained granite are frequently found passing into, and alternating with, each other, in various parts of the same bed.

Occasionally the quartz, felspar, and mica, assume a regular and well defined crystalline form, and sometimes the mica is found in considerable masses, unmixed with the other ingredients. The felspar in granite has usually a glassy lustre; but

* The term granite was first employed to designate a peculiar species of rock by Turneforte, derived from the Latin word *geranites*, used by Pliny.

it is occasionally found of an earthy nature, especially in such masses as have oeen long exposed to the atmosphere.

Granite varies very much in colour; and this arises chiefly from the tinge of the felspar, or from the presence of hornblende. The quartz and mica are usually of a grayish hue, and when the felspar is white, a grey coloured granite is the consequence. A reddish hue is produced when the felspar is tinged, of a flesh colour, by oxide of iron. Hornblende imparts a black or dark green colour. Sometimes the felspar is ochre yellow, pale gray, or blackish gray.

32. Granite not unfrequently passes by minute shades into gneiss, so that the distinctive difference is scarcely perceptible. In general, however, it will be found that gneiss has a lamellar structure, and especially that the particles of mica, or hornblende, entering into its composition, are arranged in parallel layers, whereas in granite they are confusedly mingled in all directions. The structure of gneiss, too, is more minutely granular than the general aspect of granite.

Sometimes granite approximates to porphyry in containing distinct crystals of felspar, imbedded in the general granular mass. This variety has been termed porphyritic granite. On the other hand, the porphyries often assimilate in their structure very nearly to that of true granite.

33. There is a minute resemblance between granite and the trap rocks, both in their structure and their obvious origin, which will be more particularly noticed afterwards. Thus many species of granite, where hornblende predominates, can scarcely be distinguished from some of the varieties of greenstone and basalt.

VARIETIES OF GRANITE.

I.—CONSISTING OF TWO INGREDIENTS.

Quartz and Felspar.—This variety occurs where there is a uniform mixture of these ingredients, and where the quartz and felspar are imperfectly crystallized, and influence each other's forms. This has been called *graphite granite.* It occurs chiefly in granitic veins that traverse gneiss, and a section of it when polished exhibits a resemblance to written characters. It is found in Arran, Corsica, Uralian Mountains, &c.

Felspar and Hornblende.—This occurs — large grained, or the hornblende crystallized, a uniform granular mixture, or intimately blended — very frequently in Aberdeenshire, accompanying the ordinary granite, at Pitcaple. Specimens of these are exactly similar to greenstone and basalt.

II.—CONSISTING OF THREE INGREDIENTS.

Quartz, Felspar, and Mica.

1. An uniform mixture of the different ingredients, constituting the most common kinds of granite.
2. Distinct additional crystals of felspar, imbedded in the general mixture, or porphyritic granite, found in Cornwall.
3. With common and glassy felspar.
4. The quartz felspar and mica distinctly crystallized—Bennachee, Aberdeenshire, Mount St Gothard.

Quartz, Felspar and Hornblende.

This is the syenite of most writers, so called from the island of Syene, in Upper Egypt, where it was known to, and used by, the ancients. Very common in Scotland.

Varieties of this rock, containing the additional minerals of actinolite, chlorite, and talc, are also occasionally met with. Granite, with the four ingredients, quartz, felspar, mica, hornblende, forming a syenitic variety, is also sometimes met with; and has sometimes been called protogine, (primævi.) Mont Blanc is composed of this rock.

34. Granite contains various minerals, either imbedded or traversing it in veins, as quartz crystals, shorl, topaz, beryl, garnet, fluor spar, tourmaline, emerald, jade, lapis lazuli, &c. &c.

Metalliferous veins are not found extensively in granite. Tin is found in the granite of Cornwall and in Saxony; iron mines are worked in the granite of Piedmont; and mines of brown iron ore exist in the Pyrenees. Iron pyrites are often disseminated through granite, and traces of all the other metals are occasionally met with.

35. Granite is a universally diffused rock, and a great proportion of the highest and most extensive mountain ranges throughout the globe, are either wholly or partially composed of this material. Indeed, it is to be presumed, that it forms the greatest proportion of the solid base of the crust of the globe, over which the other strata are disposed. On this account, and from its containing no traces of organic remains, either of the animal or vegetable kingdom, it has been supposed to have been the first formed rock, and hence has been classed among the primitive or primary strata.

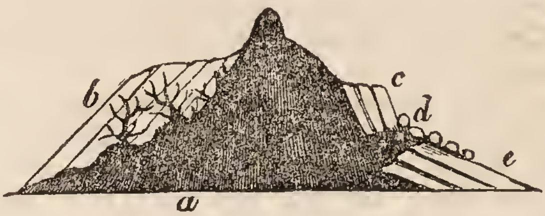
36. That granite must have existed at the earliest period of the earth's history, is evident, because its disintegration and decay have furnished the materials from whence many rocks, as gneiss, mica, schorl, of the secondary strata, have been formed:

at the same time, there are other facts which would indicate that granitic elevations have been extensively produced at a subsequent period.

Thus, veins of granite have been found shooting from the mountain mass into the strata immediately overlaying, which evidently had been formed and consolidated previous to the irruption of the granitic mass.

Very distinct illustrations of this fact are to be found in Glen Tilt.

No. 3.



In this section, *a* represents a granite mass which has been protruded and has broken up the strata, *b* and *c e*. Veins of granite are seen intersecting the fissures of the strata, *b*, and the fragments of the broken strata are represented at *d*.

Again ; the gneiss and schistose strata, most commonly found reposing on the sides of granite mountains, are so disposed in an inclined position, and in many cases are so distorted and broke up at the points of contact, as to afford strong indications of having been thus raised from the horizontal position into the inclined or vertical, by the intrusion of the central granite mass.* The manner in which the strata are arranged, also proves, in many cases, their horizontal deposition, previous to the irruption of the granite from below.

The mere absence of organic remains, then, which forms a universal feature of all granites, is not a sufficient reason for conjecturing that such rocks were, in every instance, formed before the existence of organized beings on the earth.

37. Although granite is apparently a very hard and impenetrable rock, yet many of its varieties are extremely liable to be decomposed by the action of the atmosphere. It is true,

* Supposing granitic rocks to be elevated from below upwards, from a cause analogous to that of volcanic influence, Mr Lyell proposes for them the appellation of Hypogenous, from υπο and γινομαι produced under. The term granite, however, seems to us quite unexceptionable : it implies no theory, and involves no equivocal meaning.

several Egyptian and Roman monuments, composed of this rock, have remained almost entire for two or three thousand years, notwithstanding continual exposure to the elements; but, on the other hand, many granites are found to decay and moulder into sand and clay in a very short period. Those granites in which the felspar contains an excess of soda or potass, are found to moulder away most rapidly. The felspar first gives way and crumbles into sand and dust, which, washed down by the rains and accumulated in the valleys, forms clay; the mica gradually disintegrates, and the quartz particles, by long continued attrition, by degrees pass into sand, or if of larger size, form round and angular pebbles. The syenitic granites containing a large proportion of hornblende, pass by attrition into dark blue and black masses of clay.

There is great inequality in the friability of granite, even in the same mountains, and within the space of a few yards. In this way, by partial decompositions, huge masses or blocks, and peaks of granite, are left in detached positions, often forming bold and picturesque objects. Of this description, are the granite mountains of Arran, the Logging Stone and Cheese Wring in Cornwall, the bold granitic ridges of the Riesengeberge, some of the mountains of Switzerland, the Hartz mountains in Germany, and the Carpathian and Siberian mountains.

Some granites, in decomposing, assume a globular form, and fall off in concentric circles, or in large rhomboidal masses, in this respect bearing a strong affinity to the decomposition of trap rocks.

38. When granite rocks approach the surface, the country has generally a bold and rugged appearance; most commonly the mountains have a peaked and precipitous summit. In cases where the rock is of a soft nature and liable to decomposition, the hills assume a rounded and smoothed appearance. Granite may often form the mass of a mountain, although it does not appear on the surface at any point, but may be completely covered with the overlying strata through which it has not penetrated: in this case the mountains are generally flat and unshapely.

The soil formed from the decomposition of granite is in general the reverse of fertile; and from the dense and compact nature of the rock not permitting the moisture to sink deep, a constant coldness and chillness is produced, which lowers the temperature of the country and retards vegetation.

39. Although it is presumed that granite forms the general base of the crust of the globe, yet in many extensive portions of the earth the superincumbent strata are of such depths as to conceal all traces of it. It is, however, visible in the following localities.

Europe.—Melville Island. Greenland—Finland—Cornwall in England. In Scotland, Western Islands, Dumfriesshire—Grampian range, Caithness, Sutherlandshire. In Germany, Hartz Mountains—Saxony—Black Forest—Alps of Switzerland and Savoy—Tyrol. Austria, Carpathian mountains—Pyrenean mountains, &c.

Asia.—Caucasus—Kolywan, Siberia, Uralian, Altain, and Himmala range.

Africa.—Mountains of Upper Egypt—Atlas Mountains—Cape of Good Hope.

America.—New York, Pennsylvania, and Virginia, but only sparingly. In Mexico, at Acapulco—Andes—Venezuela—sides of the Oroonoco and coasts of Peru—Cape Horn, &c.

40. Granite forms an excellent material for architectural purposes and for street paving. From its hardness, and being unstratified, it is more difficult to work from the quarry than many other rocks, but this is recompensed by its durability. Many of the ancient monuments and pillars, especially the Egyptian, are composed of granite. For common purposes of architecture, it is usually dressed with a sharp pointed instrument into the proper shape, but it may also be chiselled and polished like marble or sandstone.

SECTION V.

TRAP OR GREENSTONE ROCKS.

41. These rocks consist of several species, which have been all comprehended under the general name of trap, from the Swedish word *Trappa*, a stair.

They are composed chiefly of felspar, hornblende, augite, and quartz. These ingredients are in various proportions in different species, sometimes one only being present, in other cases two or more.

These rocks are of igneous origin, having a structure approaching closely to granite, though, in general, less crystalline, and containing hornblende instead of mica. They are

found very generally diffused over the globe, and appear distinctly to have been protruded from below in a fused state, and to have broke through, shattered, and greatly disturbed the sedimentary strata which had been deposited above.

42. From this circumstance, the relative age of many of the trap rocks is pointed out. They intersect all the members of the secondary strata in such a manner as to shew that they were forced up after these strata had been formed and consolidated.

It is probable, too, that the trap rocks are of later origin than the older granites.

43. Greenstone (in French *Diabase*) is by far the most common species of trap. It is composed of felspar and hornblende in nearly equal proportions, is of a dark green or grayish colour, generally fine grained, varying to a coarser crystalline form. Sometimes it is of a laminar structure, and not unfrequently assumes a columnar figure. The felspar is either white, or yellowish, or red, or sometimes of a gray or blackish hue. Greenstone is found very commonly in the coal strata of Scotland, and of England, in various parts of the continent of Europe, in America, and throughout other regions of the globe. It forms the rock of Salisbury Crags, and various other hills around Edinburgh. A greenstone approaching to syenite constitutes Corstorphin Hill in the vicinity of Edinburgh. It contains, besides the usual ingredients, a portion of prenhite and augite.

44. Claystone.—This rock has a dull earthy fracture; is softer than greenstone, and less crystallized; has an irregular laminar structure, and a gray, brown, or reddish colour. When tinged with iron, it is called clay-ironstone.

45. Wacke is a similar rock, somewhat intermediate between claystone and basalt. Both these rocks are found on the Calton Hill and Arthur's Seat, near Edinburgh.

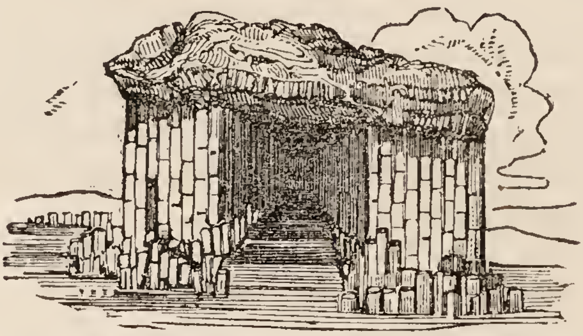
46. Clinkstone (or phonolite) is so called from the ringing sound which it gives when struck. It is very hard, and not easily scratched with a knife. Its fracture is conchoidal, the edges are slightly translucent. It is of a brown or greenish gray colour, of a uniform massive structure, not crystallized. It is frequently intersected by veins of jasper. It is composed chiefly of silica and alumina, with a small portion of lime, soda, and oxide of iron. Blackford Hill, near Edinburgh, is chiefly composed of it.

47. Compact Felspar, or hornstone, is hard, compact, of a

reddish lustre, edges translucent, and conchoidal fracture. It occurs in veins and beds.

48. Basalt.—This rock is of a dark green or black hue, is composed of hornblende compacted into a solid mass, with crystals of augite imbedded in it. It is hard, glistening, and of varied lustre. It assumes many varieties, and passes, by imperceptible degrees, into greenstone and clinkstone. It usually assumes a columnar form,—these columns being jointed with regular angular sides, and affording specimens of true crystals many feet in length. The rocks on which the castles of Stirling and Edinburgh are situated, have this columnar structure. A magnificent range of basaltic columns, form the celebrated Giant's Causeway in the north of Ireland; and the Isle of Staffa is wholly composed of this substance. Fingal's Cave, in Staffa, is one of the most splendid natural objects in the world. It was first pointed out to the admiration of the public in 1772 by Sir Joseph Banks, and is described by the late Dr M'Culloch.

No. 4.



The entrance to this cave resembles a Gothic arch, about 70 feet high. It is in breadth from 40 to 50 feet, and 227 feet long. The sides are composed of a series of columnar masses of basalt, arranged with considerable regularity, which support a roof of the same material, while the ocean laves the base. Were it even destitute of that order and symmetry, that richness arising from multiplicity of parts, combined with greatness of dimensions and simplicity of style which it possesses; still the prolonged length, the twilight gloom, half concealing the playful and varying effect of reflected light, the echo of the measured surge as it rises and falls, the pelluicd green of the water, and the profound and fairy solitude of the whole scene, could not fail strongly to impress a mind gifted with any sense of beauty in art or nature.

49. Amygdaloid.—This is composed of a basis of greenstone or claystone, which originally has been of a porous lava-like nature. These porous cavities have afterwards been filled up by a fluid solution of mineral substances, and consolidating have formed nodules of calcareous spar, agate, chalcedony, zeolites, green earth, and glassy felspar. The eastern range of Arthur's Seat, and the Pentlands, near Edinburgh, afford specimens of this rock.

In Derbyshire it has received the name of Toadstone.

50. Pitchstone.—This is a glassy looking green coloured rock, of rather rare occurrence among the trap family. It is found in veins of some breadth, in the Island of Arran; and is not unlike the obsidian of volcanic origin. Sometimes it has crystals of felspar imbedded, forming a porphyry.

51. Serpentine.—This beautiful mineral may, perhaps, be best classed among the trap rocks. It is of a greenish variegated colour, has a soft soapy feel, and a strongly argillaceous odour when breathed on. It is found in contact with granite at Portsoy, north of Scotland, and among trap rocks in Cornwall.

52. Diallage is nearly allied to serpentine in appearance, and is found associated with that rock.

53. Porphyry.—This term was originally applied to certain reddish minerals capable of taking a polish. Thus, Pliny speaks of *marmor porphyrites* as common in Egypt. The term is now applied to all those rocks having a compact basis, through which are scattered crystals, or grains of some other mineral. The nature of this base gives the name to the porphyry. There are several varieties.

Claystone porphyry,—a base of claystone, with crystals of felspar.
Greenstone porphyry, { base of greenstone, with crystals of felspar, quartz, or calcareous spar.
Felspar porphyry,—with base of felspar, and crystals of quartz or mica.
Pitchstone porphyry,—with base of pitchstone and crystals of felspar.

Porphyries have the same igneous origin as the trap rocks. They range through various strata, and are sometimes found in conjunction with granite and the primary rocks.

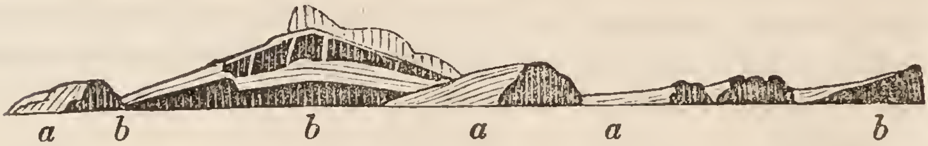
Porphyry forms the summit of Ben-nevis, while the base is granite. A bed of claystone porphyry is found in conjunction with granite in Peru.

Porphyry forms a considerable portion of the Calton Hill and Arthur's Seat, near Edinburgh.

54. Trap rocks are very soon acted upon by the atmosphere, and thus crumble down into minute particles, which form a rich soil for the agriculturist. Some fantastic rocks, half worn away by the action of the elements, are found in the Isle of Sky, which assume the appearance of ruined castles, spires, and arches. The stone is not much used in architecture, but is extensively employed as material for roads, for which it is excellently adapted.

Many districts appear to have been elevated from the bed of the ocean by the agency of trap rocks in a similar manner, as the older strata by the granite mountains. A considerable part of Scotland has thus been raised by a chain of trap mountains, which range from the Western Islands to St Abbs head on the east shore.

No. 5.



This section exhibits the sandstone strata as elevated around Edinburgh. *a a a* Sandstone originally in a horizontal position; *b b b* Trap rocks which have been thrust up in a fused state through the strata lying above.

55. Volcanic Rocks.—Lava, which is the production of volcanoes at present in action, so nearly resembles many of the trap families, as to leave no doubt of the similarity of the processes by which both have been formed. In general, however, lava is lighter, more porous, and less crystalline than trap, and this may be owing to its production under less pressure than that under which the trap rocks have been thrown up. As volcanic action falls to be considered under the head of agencies still going on upon the earth's surface, the subject will be resumed afterwards.

SECTION VI.

PRIMARY STRATIFIED ROCKS.

56. Gneiss.—Gneiss is composed of the same materials as granite, containing either two or more of the four ingredients of that rock, quartz, felspar, mica, and hornblende. It is

distinguished from granite, however, in the manner in which these different substances are arranged. Gneiss has a laminar stratified form, the quartz and felspar being divided by alternate thin layers, either of mica or hornblende ; in general, too, the particles composing it are more minutely granular than in the other rock, although varieties of it are so large grained, as to pass into common granite.

The colour of gneiss varies as much as that of granite. It is usually greyish or reddish white, but of a darker tinge when hornblende is present instead of mica. It is usually hard and compact, breaking in a position parallel to the layers of stratification, but it is also found of a soft friable nature, especially those varieties which pass into mica slate.

57. Gneiss forms in many countries strata of great thickness, constituting extensive districts, and forming high mountain ranges ; most frequently it is found resting in immediate contact with granite rocks, but it is also found alternating with quartz rocks, mica schist, hornblende slate, and others ; in these alternations, the strata of gneiss is frequently very thin and inconsiderable.

The distinctness of the stratification of gneiss varies much, according to circumstances. Where it approaches closely the structure of granite, the stratification is scarcely discernible ; in general, the marks of distinct layers are very evident, and especially where alternating dark layers of hornblende schist exhibit a distinction of colour. Usually the smaller laminæ are parallel to the larger layers of stratification.

The inclinations of the strata vary infinitely from the almost horizontal to the perpendicular, and appear to be influenced entirely by the subjacent rock, following accurately its bends and projections.

Frequently, at the point of junction with granite, the strata of gneiss are found greatly contorted, exhibiting all manner of curved, waved, and angular lines. Where veins of granite, too, shoot into the gneiss,—an occurrence by no means unfrequent,—the characteristic appearance of the latter is completely changed, and it becomes almost impossible to distinguish it from the surrounding granite.

As these granite veins traverse the gneiss in all directions, they occasionally lie parallel to the strata, and alternate with these in such a manner as to put on the appearance of stratified granite, and, in fact, have often been mistaken for such.

58. Gneiss may be divided into three varieties, each charac-

terized by a peculiar structure, the granitic, the schistose, and the laminar.

The granitic variety very closely resembles granite, and varies in its component parts, colour, and degree of granulation, in the same manner as the granites do. In general, however, it may be distinguished from this rock by the appearances, more or less distinct, of seams of quartz and felspar alternating with mica or hornblende, and by splitting at those seams when fractured.

Variety, 1. Quartz, felspar, mica.
2. Quartz, felspar, hornblende.
3. Quartz, felspar, mica, hornblende.

Variety, 1. White felspar and quartz in minute grains with few scales of mica.
2. Do. Do. mica abundant.
3. Foliated mica, with large crystals of felspar.
4. Undulated coarse schist, felspar, and quartz, large grained.

The schistose variety has decidedly the slatey structure, and may easily be split into layers; it is marked by parallel coloured streaks, from the distinct arrangement of its various coloured particles. This variety passes into quartz rock, if hornblende and mica be wanting, usually of a fine grain and whitish hue. If the felspar be deficient, and the mica abundant, it passes into mica slate.

The laminar variety is not so common as the other two. In it, the quartz, felspar, and mica, in minute particles, are arranged separately in regular laminæ; and the rock has a streaked appearance, alternately red and white, from the successive layers of the felspar and quartz, which predominate over the mica in its composition.

Several other minerals occasionally enter into the composition of gneiss, and affect its structure and appearance, such as chlorite, talc, actinolite.

Compact and white fine granular felspar enters into the composition of gneiss, forming the white stone of Werner, in which are imbedded garnets, &c.

59. Gneiss is rich in metallic veins, almost all the metals being found in it, and many in considerable quantity. The Saxon, Bohemian, and Saltzburgh mines, are situated in this rock, and tin, copper, lead, and silver, are extensively worked from veins in gneiss.

This rock, like granite, which it accompanies, may be said

to be universally distributed over the globe. It is found extensively in Norway, Sweden, Saxony, Bohemia, Carinthia, in the Alps, Pyrenees, in North and South America, forming extensive ranges. The mountains composed of it do not rise to such bold and abrupt peaks as those of granite, and it is more liable than that rock to decay and disintegration from the action of the elements.

60. No organic remains have been found in gneiss ; and as it is, in all probability, a mechanical deposit from the disintegration of older rocks, this circumstance would lead to the inference, that, at the period of its formation, no animals existed, or that their numbers were exceedingly limited on the earth. In the more recent deposits that bear evidence of having a similar origin, we shall find that organic remains, especially of marine animals, are in great abundance.

That the gneiss, in immediate contact with granite, has undergone a considerable change analogous to fusion, is also apparent in a great variety of instances, — thus resembling the effects which trap rocks produce when they come in contact with sandstone. That this fusion, however, would be sufficient, according to the theory of Lyell, to destroy all traces of organic remains, is not at all probable, especially as continuous strata of the same gneiss may often be seen passing into soft and friable mica schist, that bears no marks of fusion or disturbance from the placidity of original deposition.*

61. Mica Slate, or Schist, is a composition of quartz and mica, with occasionally a small proportion of felspar. Its different varieties depend on the superabundance or deficiency of mica, on the coarseness or fineness of the granulated particles, and on its containing felspar, when it then passes imperceptibly into gneiss. If the particles of mica are in very small proportion, it assumes exactly the form of quartz rock.

Mica slate is of a laminar structure, of a greyish colour, passing into various darker shades, according as it contains dark coloured mica or other ingredients. It is fissile, or splits into parallel layers. The laminæ, composing these layers, are frequently undulated, but not usually so contorted as

* Dr M'Culloch notices a very interesting instance in the Isle of Skye, where gneiss passes into and alternates with strata of red sandstone. The gradation is effected by the interposition of chlorite schist, passing, on the one hand, into gneiss, and in the other, into mica schist and sandstone. Red sandstone is evidently a mechanical deposit ; this affords a strong illustration of the similar formation of gneiss.

gneiss. Nor is mica schist found so often penetrated by granite veins as the latter rock, although veins of quartz very commonly traverse it.

Although the minute laminæ of mica schist generally lie parallel to the greater lines of stratification, yet it appears sometimes as if these laminæ—especially when much waved—were arranged at angles, somewhat intermediate between the perpendicular and parallel planes of stratification.

62. Mica schist forms extensive strata, usually lying above gneiss, and intermediate between this rock and the argillaceous schists, with all which, however, it alternates. The thickness of the strata vary as in the case of gneiss. When alternating with the other slates, the strata is sometimes of extreme thinness : when unaccompanied by them, the mass is of great thickness and extent.

In texture mica schist is either crystalline, granular, or laminar, and more or less hard and compact according to circumstances.

A coarser grained schist occasionally occurs, especially in alternations with other rocks, where fragments of quartz rock, limestone, clay slate, and greywacke, are intermixed with the mass, thus affording an unequivocal proof of the mechanical origin of the deposit. At the same time, it is evident that the common cement of mica schist is a crystalline mass of quartz, which bears marks of chemical fluidity.

Hornblende, chlorite, and talc, are occasionally combined with mica schist, as well as several other minerals, which modify its character and appearance.

This rock is also rich in metals, but they occur more frequently in beds and masses than in veins. Iron, copper, arsenic, lead, cobalt, silver, and gold, are of frequent occurrence, accompanied with actynolite, garnet, and asbestus.

Like the preceding rocks, mica slate is found in all the regions of the globe. In Scotland it forms extensive tracts of country to the north-west of the Tay. It prevails in Germany, Switzerland, France, Spain, in North and South America, and in Africa and Asia.

The mountains formed of this rock are less elevated than granite, or even gneiss, and are flat and round backed.

VARIETIES.

Mica and Quartz.

1. Laminar, with the mica in excess, and beautifully coloured by two shades of mica, white and black.
2. Laminar, with quartz in excess, and thin laminæ of mica.
3. Laminar, with the mica greenish, passing into chlorite schist.

Granularly Laminar.

1. Granular quartz, uniformly mixed with scales of mica.
2. Granular quartz, occupying distinct laminæ.
3. With distinct scales of mica interspersed. Compact varieties of this, of a reddish yellow colour, form the mineral avanturine, which receives a fine polish.

Mica, Quartz, and Hornblende, or Felspar, or Chlorite.

Varieties of all these occasionally occur, passing into gneiss and chlorite, or hornblende schist.

A rare variety, containing carbonate of lime, is found in Perthshire, and conglomerated mica schist is found in the Western Islands of Scotland.

63. CHLORITE SLATE. — This is composed of quartz and foliated chlorite. In its texture it resembles mica slate, but it is of a green colour, from the peculiar tinge of the chlorite. It is found in strata, lying on, and alternating with, gneiss, mica slate, and clay slate, but it is not so universal or abundant as any of these rocks. Its varieties depend on the granulated or foliated structure of the ingredients, or on the addition of mica, felspar, and hornblende.

64. TALCOSE SLATE. — This rock is of less frequent occurrence than the preceding. It is a compound of quartz and talc, with occasionally some one or two of the ingredients entering into the other schists. From these it is readily distinguished by the peculiar soapy feel of the talc; its colour is white, lead grey, or dark green.

65. HORNBLENDE SLATE. — This rock is a compound of felspar and hornblende, or sometimes consists of hornblende alone.

It does not exist in an independent form, or to a great extent. It is the primitive greenstone or hornblende rock of some geologists. Its texture is crystalline, and it is doubtful whether, like the other slates, it be of mechanical origin. According to Dr M'Culloch, it rests on and accompanies gneiss, observing all the wavings and contortions of that rock. It forms the mountain of Ben Lair in Ross-shire.

66. Quartz.—This rock consists either of pure quartz or a mixture of quartz and felspar, or of one or both these ingredients combined with mica, when it passes into gneiss and mica slate.

It is sometimes, but rarely, found in a compact crystalline state, differing little from pure quartz, as it is found in veins. Even in this state it shews a tendency to divide into parallel beds ; and throughout all its modifications it is of a lamellar nature, and disposed in a stratified form.

More generally it is a granular aggregate, cemented together by a basis of crystallized quartz. The grains vary in size, and the texture of the rock passes from a hard compact to a somewhat loose arenaceous mass.

A third modification exhibits the grains large, rounded, and more sparingly scattered through the mass, evidently indicating a mechanical origin. Frequently, in all these varieties, cavities are found containing minute quartz crystals, shewing that the cementing basis must have been in a fluid state.

67. The next and most common variety of this rock consists of a mixture of quartz and felspar. It varies in texture, the grains of felspar being sometimes imbedded in a crystalline quartz, while more frequently both the quartz and felspar grains are agglutinated together in various proportions and of various sizes. In every case the texture is foliated. The tinge is often of a reddish hue, from the colour of the felspar.

Where mica is present, the rock passes into gneiss and mica slate, and can barely be distinguished in character and appearance from these rocks.

Sometimes it alternates with blue schistose clay, or mingled with fragments of granite, felspar, or quartz, passes into conglomerate and greywacke.

Quartz rock often accompanies gneiss, and is found alternating with all the primary schistose strata. Like these it is disposed in distinct layers, the division of the beds being even more strongly marked than in them. These beds vary from an inch to many yards in thickness ; and being intersected by numerous natural joints, they break into rhomboidal masses, like the schistose rocks. The strata are occasionally bent, but without those contortions so common in gneiss and mica slate.

In many respects, quartz rock resembles the secondary sandstones.

It forms large mountains and extensive strata in the Western

Islands and other parts of Scotland, and most probably will be found to prevail to a similar extent in other regions of the globe.

68. Argillaceous Slate. — Argillaceous or clay slate is composed chiefly of indurated clay, to which is occasionally added particles of quartz and mica, and, in the coarser varieties, fragments of the primary rocks, grains of felspar, &c. The prevailing colours of this slate are blue, purple, black, dark grey, yellowish, and greenish when it passes into chlorite schist. Familiar examples of all these are afforded in common roofing slates.

Beds of clay slate are invariably stratified; in thickness from half an inch to many hundred feet. The texture is laminar, separating easily into very thin plates. Most commonly the laminæ run parallel to the lines of stratification. Occasionally they lie at an oblique angle to these, and are sometimes waved and irregular, while the strata have a straight and parallel position.

The slates are found in all varieties of inclination, from the perpendicular to the horizontal.

Argillaceous schist very generally succeeds mica slate, but it is also found resting on granite, and alternating with all the other primary slates, in beds of greater or less thickness.

These strata are liable to the same flexures as gneiss and mica slate, but are rarely so minutely contorted. They are often divided by natural joints, thus forming large rhomboidal or prismatic beds.

A fibrous structure is sometimes observable in the finer varieties, and compact clay nodules are frequently imbedded, over which the laminæ rise in successive layers, accommodating their folds to the form of the nodule.

These and other peculiarities of their structure would distinctly indicate a mechanical deposition as the cause of their formation, at the same time that, in many instances, a chemical quartz cement is also apparent. This is particularly obvious in all those varieties of clay slate used as hones, where quartz is the basis of cement.

Clay slate passes by gradual transitions into gneiss, mica slate, hornblende, and chlorite slates—when coarse grained, it also passes into greywacke and sandstone conglomerates.

The varieties are: —

1. Simple compound of indurated clay alone, having a straight, even, or a rough undulated fracture. This is the most valuable for roofing slate, and

is of various shades of lead blue, purple, black, sometimes gray, or nearly white.

2. Massive and imperfectly fissile.

These do not split into parallel layers,—sometimes they break into curved laminæ. Black chalk or drawing slate is of this kind.

3. More compact, with a smooth, splintry, or minutely granular fracture. The fragments translucent, of a pale yellow colour, resembling compact felspar. This is the common hone. A harder variety contains a basis of silex, and strikes fire with steel.

4. Compound, containing mica, or talc, or chlorite, or hornblende, or grains of sandstone, larger quartz particles, calcareous spar, felspar.

5. With two or more of these ingredients combined, thus passing into common greywacke.

6. With various fragments of argillaceous schist reunited with a clayey basis.

In many cases argillaceous schist can scarcely be distinguished from clay shale, both being of similar hardness, colour, and composition ; the distinction can only, in such cases, be made by a knowledge of the position and other relative strata with which they are connected.

Clay slate contains a variety of the minerals commonly found in the primary schists already mentioned. It is also rich in veins of the different metals, as silver, tin, copper, lead, cobalt, &c. Rhomboidal crystals of iron pyrites are frequently found in common roofing slates.

Clay slate forms many extensive mountain ranges in every region of the globe. These mountains are characterized by a smooth, flat, rounded appearance, seldom or never rising into the bold peaks of granitic mountains, or even the less precipitous elevations of gneiss or mica slate.

The soil arising from the decomposition of clay slate is, however, found to be more fertile than that of either of the last mentioned rocks.

69. Clay slates are extensively used for roofing houses. Wales furnishes abundance of excellent slate for the London market. Balahulish and Easdale chiefly supply Scotland.

The writing slates are of a finer quality than the common roofing slate.

The various kinds of hones are clay slates with an admixture of quartz.

70. Primary Limestone.—This is a simple rock, consisting of carbonate of lime. In its pure state, it is granular, crystalline, and of a colour varying from pure white to grey and yellowish. It is found in irregular masses, or beds, or large nodules, with little or no appearance of stratification. More generally, however, it is regularly stratified, and these strata

alternate with other rocks, and are of all varieties of thickness.

The texture varies from a highly crystalline, of a larger or finer grain, to a compact and even earthy. Other substances are sometimes combined with the simple rock, which modify its appearance and texture, such as mica, quartz, hornblende.

It is never found in veins, except in the form of regular crystals, and, in this respect, it exactly resembles quartz.

There is considerable difficulty in drawing the line of distinction between the primary and secondary limestones, where the latter do not happen to contain organic remains. In the primary limestone, strictly speaking, no organic remains have yet been discovered. With one or two exceptions, and as a general rule, it may be said, they, like the primary schists, are almost destitute of organic bodies.

71. In Scotland, primary limestone rests in contact with granite, where it is often found indurated; and when mixed with other substances converted into a mass, which has received the denomination of chert.

In gneiss, it is found either in nodules or regular strata, and these are frequently intersected by granite veins. Where it alternates with gneiss and micaceous schist, it frequently contains a considerable proportion of mica; when it accompanies argillaceous schist, a large mixture of this substance will also be found present. Like the strata which it accompanies, beds of limestone are often bent and contorted, evidently from disturbance from below.

VARIETIES.

Simple Rock.

1. Crystalline—varying in the sizes of the granulations.
2. Compact—splintery—either with a rough or smooth fracture or conchoidal.

The colours vary from a pure white, which constitutes the statuary marble, to various shades of grey, brown, black, and green. These tints are derived from a carbonaceous matter or oxyde of iron, or an admixture of other minerals.

Compound.

1. With mica interspersed—or talc, augite, quartz, felspar.
2. With mica and serpentine conjoined, or hornblende and augite.
3. A conglomerate with limestone fragments—quartz, felspar, or fragments of the primary rocks imbedded in a calcareous base.

72. If a line of demarkation can be distinctly drawn between the primary and secondary limestones, a remarkable suggestion presents itself,—that the quantity of the latter is much greater in proportion to the former, and that the proportion of primary limestone is much less than that of the granitic rocks.

The island of Paros and the promontory of Athos, in the Archipelago, are composed of primary limestone; Carrara, in the Appenines, is famous for its marble; part of the Alps of Switzerland, the Pyrenees, and many other situations of the continent of Europe, abound with it. It is found in Perthshire, and Sutherlandshire, in Scotland, and in the islands of Tiree, Icolmkill, and Sky.

It frequently contains metals, and these occur in beds more generally than in veins; many of the minerals common to the other primary strata are also found in it.

SECTION VII.

SECONDARY STRATA.

73. A series of rocks are denominated secondary, because they evidently appear to have been formed from the fragments of the primary slates and granites, and consequently at a period after such rocks had existed on the earth's surface. In the secondary strata, also, the remains of plants and animals, in a petrified state, are found in great abundance, whereas, in the oldest rocks, no traces of such organized beings can be discovered.

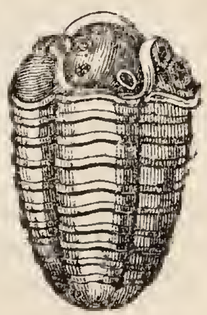
These petrifactions of plants and animals are called generally organic remains, because they exhibit the organized structure of plants and animals that have formerly existed, converted into stone. The petrifying substance is either lime or silex, which have been chemically dissolved in water. The fluid gradually insinuating itself into the minute pores of the organized body, and the water afterwards evaporating, has left solid earth, which has exactly assumed the shape and structure of the original substance. Sometimes, however, the actual shells and bones of animals are preserved among rocks.

The most remarkable circumstance respecting these organic remains, is, that, for the most part, they consist of orders and families of plants and animals that are not found to exist in the present day. In some cases, species are found bearing a

resemblance to families now on the earth, yet differing from them in many particulars.

74. GREYWACKE* is the lowest rock in the secondary series, and sometimes even alternates with layers of the primary slates. It is of a dark red or purple colour, and is composed of fragments of quartz, felspar, Lydian stone, and clay slate imbedded in a base of clayey matter. The fragments vary in size from minute grains to an inch or two inches, and are found angular and sharp edged, as well as rounded and worn down by previous attrition. It is a stratified rock, and not unfrequently passes into regular slates. The greywacke strata are generally very much inclined, and frequently quite perpendicular, and seem to have undergone much violent disturbance after their first deposition. This disturbing cause has, in most cases, been trap rock. Greywacke, and some of its accompanying strata, form the *Transition* rocks of Werner.

No. 6.



Trilobite.
Calymene Blumenbachii.

The organic remains found in greywacke consist of extinct species of reeds and ferns, common to the coal strata which lie immediately above, and of zoophytes resembling somewhat our modern corals, together with several species of shell animals, all of marine origin.† The trilobite, supposed to have been a crustaceous animal of the crab and lobster kind, is peculiar to greywacke.

Beds of limestone alternate with the greywacke, which also contain the remains of marine animals.

75. Greywacke is found in the southern portion of Scotland, in the long range of the Lammermoor hills; and commencing in the Pentlands, near Edinburgh, it extends westward through Lanarkshire and Dumfriesshire. Hence, it ranges, with breaks formed by newer deposits, or the sea interrupting, along Cumberland, and the western coast of England, into Normandy and

* From *grauwacke*, a German provincial term. The French name for this rock is *Traumete* and *psammite*.

† Such as Stigmaria ficoides, Sigillaria tesselata, Lepidodendron, Sphenopteris, Pecopteris.
Zoophytes—Madrepora, Cellipora, Caryophyllia, Flustra.
Shells — Terebratula, Producta, Pecten, Cardium, Patella, Orthoceratites.

Brittany. It is found in Norway, Sweden, and Russia, in the Hartz Mountains of Germany, and in many other parts of the old world. In North America a corresponding rock, with similar fossil remains, has also been found ; so that we can trace the identity of this formation over a considerable part of the globe, shewing that the same general causes have given rise to the whole.

76. Old Red Sandstone.—Greywacke frequently passes by imperceptible shades into a reddish brown mass, which has obtained the name of old red sandstone. This rock varies considerably in appearance : sometimes it is a small grained compact sandstone ; at other times it is found as a conglomerate, having masses of quartz and other fragments of various sizes imbedded in a sandstone, made up of finely comminuted felspar and mica.

The origin of this sandstone would appear to be disintegrated granite, with fragments of quartz and other rocks intermingled. It contains the remains of fishes of peculiar and extinct families, and the other fossils common to the greywacke. This sandstone is seen forming the cliffs of Dunnotar on the eastern coast of Scotland, and is common in many parts of the world.

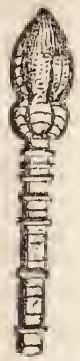
Sometimes it assumes a fine grained and hard slatey structure : the Arbroath slates, so extensively used for pavements, are of this description.

77. Carboniferous or Mountain Limestone. — This limestone exists in extensive beds, immediately below the strata containing coal, and above the greywacke series. It is of a compact structure, varying from a light grey to a dark brown or bluish-black colour, is dispersed in strata, and these sometimes alternate with clay slate, and form what the workmen denominate *blaes*. In Derbyshire, the interposed masses are of a hard siliceous nature called *chert*. This limestone is full of the remains of marine shells and animals ; so much so, as, in many cases, to appear entirely composed of such materials. It evidently appears to have formed the bottom and shores of a former ocean, although now the strata are found broken up from their original horizontal position, and forming frequently the sides and summits of mountains of considerable height.

78. One of the most common fossils in the mountain limestone is the crinoidea, or lily encrinite. The jointed stems or branches of this animal are found strewed throughout the

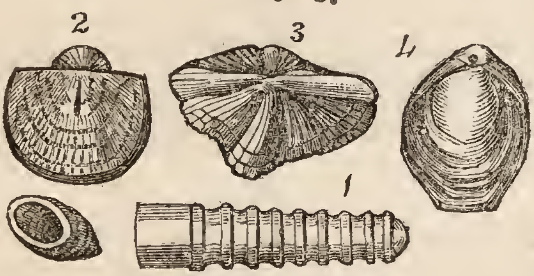
whole matter of the beds. This zoophyte, or plant-like animal, seems to have been attached to the limestone rocks, by the extremity of its long jointed stem or body, while the head, surrounded by numerous arms or tentaculæ, with the mouth in the centre, floated upwards in the sea, prepared to lay hold of its food floating about in the ocean. Several species of the crinoidea had existed in a former state of the earth's surface, extending to many feet in height, and varying according to the form of the jointed stem and the position of the arms, as Apiocrinites, pear-shaped; Moniliformis, necklace-shaped; Pentacrinis, five-sided; Briareus, many armed. Only one living animal approaching to this form has been discovered in the seas of the present time, and this is found in tropical regions. The most common shells of this limestone are here figured.

No. 7.



Lily Encrinite.

No. 8.



1. Orthocera annulata.—Productus martini.—3. Spirifer trigonalis.—4. Terebratula bidens.—5. Spiral process of S. trigonalis.

79. Beds of fresh water shells, and the remains of fishes and plants, have been discovered in this limestone, as at Burdiehouse, near Edinburgh, with numerous bodies, called coprolites, the supposed excrement of fishes and reptiles; and in such a position as to indicate that some large river had flowed into the sea at the period when those limestone beds were in the progress of formation.

Mountain limestone lies below the coal strata of the south and south-west of Scotland, stretches into the north and western counties of England; and is found to prevail in many parts of the continent of Europe, and in North America.

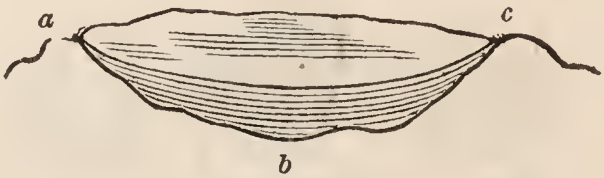
80. It is used extensively as a limestone, and being subjected to heat, forms common lime, used for mortar, and for agricultural purposes. By the process of burning, the animal and vegetable matters which impart to it a dark colour, are destroyed, and it becomes a pure white.

Lead ore is found abundantly in this limestone. Many varieties of mountain limestone receive a fine polish, and are used as marbles for domestic ornaments. It is of various colours, according to the substance contained in it, and is variegated by marine shells, alumina, iron, and other minerals. A dark blue or black variety is called Lucullite.

81. CARBONIFEROUS SANDSTONE OR COAL MEASURES.—These beds consist of alternate layers of a yellow or reddish sandstone, with clayey matter in the form of dark brown slates, of a softer nature than the primary slates used for roofing, and called clay shale; and sometimes, from their being mixed with bituminous matter, bituminous shale. Between these beds of sandstone and shale, the coal seams are interposed.

Coal fields generally occur in hollow troughs or valleys; and an idea of the manner in which they are formed, may be obtained by the following diagram.

No. 9.



Suppose *a b c* to be a hollow space or valley between two ranges of mountains, and that layers of sandstone, shale, and coal are placed alternately, one above the other, like the leaves of a book, or rather like hollow shells, so as to fill up this valley to the surface of the soil. Thus, we have a coal field, with seams of this mineral, placed one above another in succession, and extending over the whole circumference of the valley.

The sandstone composing the coal measures has evidently been formed by the wearing down of primary granites and slates; for it exhibits a compound of their ingredients, wore into minute particles, and again consolidated into a hard mass. Sometimes the particles are of a larger size, forming millstone grit, which is used for millstones and grindstones.

82. Coal has been originally vegetable matter, which, undergoing a chemical action and long pressure under the earth, has been converted into this substance.

Coal consists of bitumen, carbon, or charcoal, and carburetted hydrogen gas, varying in proportions in different kinds.

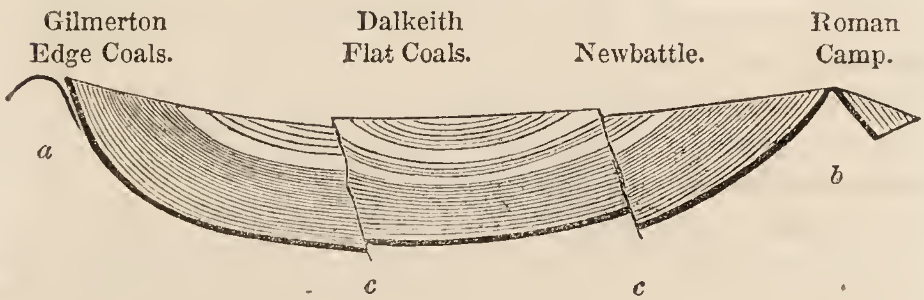
The roofs and bottoms of the coal seams are found to be lined with innumerable stems and leaves of plants; and these

are also scattered through the centre of the seams, but are less easily distinguished there, because the pressure and chemical action have been greater. Large trunks and branches of trees are also found plentifully among coal fields, with the bark and substance converted into coal. The chemical ingredients of coal, too, are such as could only be obtained from vegetable matter; so that no doubt remains but that this mineralized substance has had a vegetable origin.

The coal strata bear evident marks of having been deposited by the gradual and long continued action of rivers flowing into the ocean; and probably, in some cases, and at some periods, by the rapid growth of trees and other vegetables in the spots where they are now enveloped.

But the coal strata, as we now find them, are not in that regular order in which they would appear to have been originally deposited: they have been since deranged and elevated partly by the unequal consolidation and consequent separation of various portions of the coal valley; but chiefly by the intrusion of igneous rocks from below, by which they have been elevated far above their original level, and broken up and interrupted by numerous slips or faults.

No. 10.

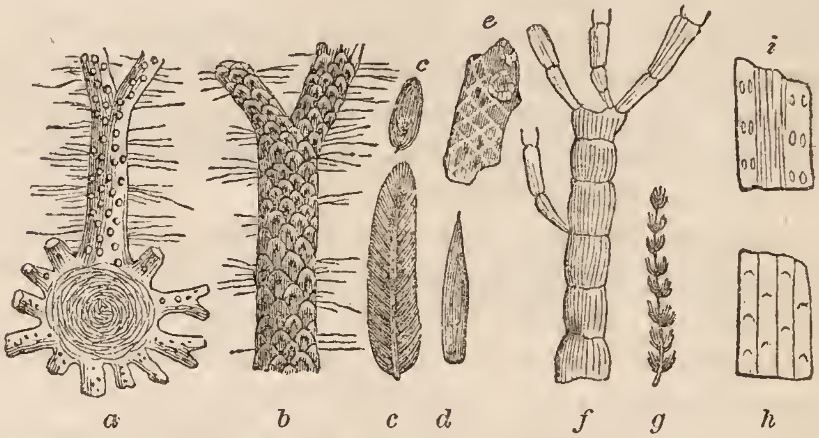


This figure exhibits a section of the Edinburgh coal field, where a few of these interruptions and faults are delineated. *a* and *b* represent the intrusion of trap rocks, by which the coal strata have been very much raised up and distorted; *c c* are slips or faults of the strata, caused by the unequal sinking of the two fissures, which may be supposed to have originated by dykes of trap rocks traversing the coal field.

83. The vegetables discovered in the coal strata consist of a variety of species, all differing from plants at present in existence. They chiefly consist of those plants allied to ferns, reeds, and some species of palms, resembling altogether plants of a tropical climate. Of the trees, the greater proportion

belong to the coniferæ or pine family, some specimens of which have been discovered forty-seven feet in length. These coniferæ resemble the araucarias of New Holland and South America, much more than they do any pines at present natives of these northern regions. The following are the most common vegetable remains of the coal measures.

No. 11.



a Stigmaria ficoides — *b* Lepidodendron Sternbergii — *c* Lepidostrobus variabilis, the supposed seed of Lepidodendron — *d* Lepidophyllum lanceolatum, supposed leaflet of Lepidodendron—*e* Ulodendron—*f* Calamites Mougeotii—*g* Calamites Nodosus—*h i* Sigillaria.

The stigmaria ficoides is one of the most common plants in the coal measures ; and from all we can learn of its structure, perhaps one of the most singular. Contrary to the usual erect position of plants, it seems to have grown horizontally, spreading out its flat leaves near the muddy soil. The nature of its stem is unknown, but the central junction of its leaves forms a knot of three feet in diameter. The leaves appear to have been cylindrical and fleshy, like the cactus. They are marked with numerous raised round protuberances or dots, from whence the leaflets sprung.

The calamites and equisetæ have hollow jointed stems, and greatly exceed in size any plants of the same families now known.

The lepidodendron, of which there are several species, seems to have been a splendid plant, something intermediate between arborescent ferns and the pine tribe.

84. The beds or seams of coal vary in thickness from half an inch to 6, 10, and even 30 and 80 feet, the average of workable seams being three to four feet. These are very numerous in some coal districts, but only a few of them are workable. The depth of the whole strata of the Edinburgh and New-

castle fields may be from 4000 to 5000 feet; but the deepest coal seam wrought is about 1800 feet; very frequently the seams approach within a few feet of the surface.

Coals are obtained by first sinking a perpendicular shaft down through the strata, until it arrives at the coal seam to be worked. Then the coals are quarried out by blasting them with gunpowder, and proceeding in the direction of the seam sometimes for miles below ground, pillars of coal being left at regular intervals to support the roof of the pit. Steam engines are employed at the mouth of the pit to draw up the coals in buckets, and to pump out the water which flows into the tunnels from numerous springs running in the strata.

Carburetted hydrogen gas, too, or fire damp, often makes its escape in the process of quarrying out the coals. The danger from this explosive substance is obviated by using the Davy lamp, which is a common oil lamp covered with a fine wire gauze, a contrivance that effectually prevents the communication of flame to the surrounding air. Large fires are kept burning at the bottom of the shaft, by which a free passage of air is produced through the whole mine.

Coal fields are found in various parts of the globe, and in general, there is a great similarity between those fields in the nature of their accompanying strata and their fossil plants. Occasionally, however, exceptions to this rule occur. Sometimes coal seams are found lying on granite, as at Brora, Sutherlandshire; and in the south-eastern counties of England, coal is found partially among the lias and oolite beds.

85. In Scotland, the chief coal districts are Mid-Lothian, the southern part of Fifeshire, Stirlingshire, Lanarkshire, Ayrshire, and Berwickshire.

Ireland contains several coal fields.

In England, the great northern coal field extends through Northumberland and Durham. Coal is found in Derby and Nottingham-shires, and extends through the western counties to Wales, where there are extensive fields.

On the Continent, coal exists in France, Flanders, Sweden, and several parts of Germany, but in the more southern parts of Europe it is of rare occurrence. It is also found in China, India, and New Holland; and in America in inexhaustible abundance in the great valleys to the westward of the Alleghany Mountains.

The annual consumption of coals in Glasgow amounts to 870,000 tons, that of Edinburgh about 350,000.

From Newcastle and Durham are annually exported about 3,000,000 of tons, chiefly for the London market, so that the expenditure of this fuel is immense, and has been calculated for the whole of Great Britain at sixteen or eighteen millions of tons. Yet there is no fear of exhausting the supply, as it has been calculated that from the Newcastle fields alone there is a quantity equal to the consumpt of a thousand years, and the Welsh coal fields, but lately had recourse to, are estimated to be equal to the supply of the whole of England for two or three thousand years.

What a magnificent idea this imparts to us of the provident arrangements of nature, by which an almost exhaustless supply of the former vegetation of the globe has thus been stored up to cheer the gloom and inclemency of our frigid northern clime!

The arrangements by which the coal seams are broken up and interrupted by slips and faults, although at first they might appear defects, are yet of the utmost service; such derangements of the strata often interrupt the flow of water which would otherwise obstruct the mining operations, and also, by bringing the beds of coal nearer the surface, immense labour and expense is saved.

Iron ore is found generally to accompany coal in extensive beds; and this, too, exhibits a careful arrangement, for thus the most useful of the metals is accompanied by the fuel which is indispensable in the process of its smelting.

86. The New Red Sandstone, or variegated sandstone, lies above the coal measures, but with its strata in an unconformable position to those on which it is placed. In appearance, this sandstone is very similar to that of the coal measures, but it is evidently a different deposit. In England, this sandstone commences at Tynemouth and extends in a south-westerly direction as far as Cheltenham, covering the surface of the counties of Durham, York, Nottingham, Stafford, Warwick, Cheshire, and Shropshire. In it both vegetable and animal petrifactions occur, although sparingly, of a similar nature to those of the coal measures. It also contains beds of gypsum and rock salt.

It consists of subordinate formations, which may be divided into upper, middle, and lower beds.

The lower beds consist of a coarse conglomerate, cemented by a ferruginous sand or marl, the middle beds of magnesian limestone, and the upper of sandstone or marl.

87. Magnesian Limestone is found lying above the sand-

stone conglomerate. It is of a yellowish and reddish brown colour, is stratified, passes from a rock of some hardness to a soft friable matter, and contains spherical crystallized bodies called dolomite; sometimes it is cellular. When rubbed, many kinds of it emit a fetid smell. It contains few organic remains, and these consist of shells and fishes. It furnishes a durable building stone, may be polished as a marble, and is burnt for lime.

In Germany, a modification of this limestone has received the name of *Muschel kalk;* it is there of a smoke grey colour, contains numerous marine shells, and the lily encrinite, (Encrinites moniliformis.) *The Zechstein* of Thuringia is supposed to be identical with the magnesian limestone; it has a fetid smell, contains remains of marine shells and fish, copper and iron pyrites, and is a durable building stone.

In England, magnesian limestone extends from the Tyne to Nottingham, in strata in some places of 150 yards in thickness.

Above the magnesian limestone lie the upper beds of the new red sandstone and marl. In this sandstone are contained beds of gypsum, or sulphate of lime, and rock salt.

88. The valuable material of muriate of soda or common salt is found in considerable quantity dissolved in the waters of the ocean; also in salt springs issuing from the earth, in various kinds of strata, and in beds or masses, sometimes of immense extent, in the new red sandstone formation. Various opinions are entertained regarding the original production of such beds. By some it is supposed that the salt has been deposited by the gradual evaporation of inland salt lakes, the muriate of soda, the least soluble of the salts, being first precipitated, while the other salts that are more easily dissolved in smaller proportions of water, have been drained off, thus leaving a bed of pure salt. Others, again, have conjectured that salt is a chemical production, formed by the decomposition of granite and other rocks containing a large proportion of soda. Rock salt, when dug from the pit, has a reddish hue, being tinged by iron and other impurities, from which it is freed by repeated solution and crystallization.

Rock salt is found in England, at Northwich in Cheshire, and Droitwich in Worcestershire, besides several salt springs in the northern counties, and in Leicestershire. In France, in the salt springs of Salins, in Switzerland, Spain, Hungary, Poland, and various other places on the Continent of Europe. It is abundant in the deserts of Caramania in Asia, in the table land

of Tartary, in Thibet and Hindostan, in Caffraria, near the Cape of Good Hope, and in both North and South America. Rock salt has also been discovered in New South Wales; so that this important substance seems universally diffused over the globe.

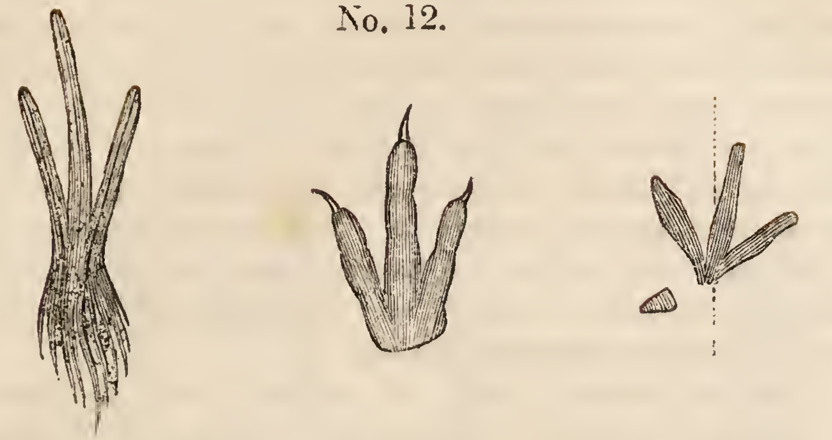
The salt district of Cordova in Spain comprehends the hill on which the town is situated, and the environs for several miles. The surface is almost every where covered with vegetable soil to the depth of six inches or more, which renders it productive. The rocks of salt form a valley a mile in length, and half a mile in breadth. The principal of these rocks is 663 feet in height, and 1220 feet in diameter at its base. A chain of hills of salt traverses the whole valley. The mountain of red salt is so called because that colour predominates; but the colours vary with the altitude of the sun and the moisture of the air. A little stream runs through the valley. All these mountains contain crevices and chasms, having spacious grottoes, where various shaped stalactites of salt hang from the roofs. Nothing can compare with the magnificence of the spectacle which the mountain of Cordova exhibits at sunrise. Besides the beautiful forms which it presents, it appears to rise above the river like a mountain of precious gems, displaying the various colours produced by the refraction of the solar rays through a prism.

The salt mines of Weeluska, near Cracovia in Poland, are the most extensive and most celebrated in Europe. They are worked at the depth of seven hundred and fifty feet. The mine extends under ground for upwards of a league. It has numerous galleries, and a whole village, containing many workmen, with their families, horses, waggons, &c. It is remarkable, that in these mines of rock salt there are springs of fresh as well as salt water.

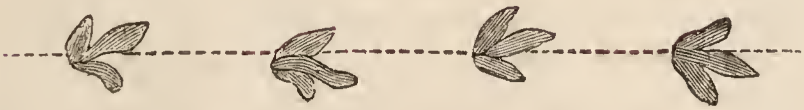
89. In the new red sandstone of Massachusetts, North America, numerous impressions of the foot-marks of several species of birds have been lately discovered by Professor Hitchcock.

This sandstone covers a large extent of country, and now lies inclined at an angle of thirty to forty degrees; but when impressed by the feet of these birds, it must have been horizontal, and have formed the soft and yielding sands of some bay or estuary. These impressions have been called Ornithichnites, from ορνισ and τιχνοσ *stony bird tracts.*

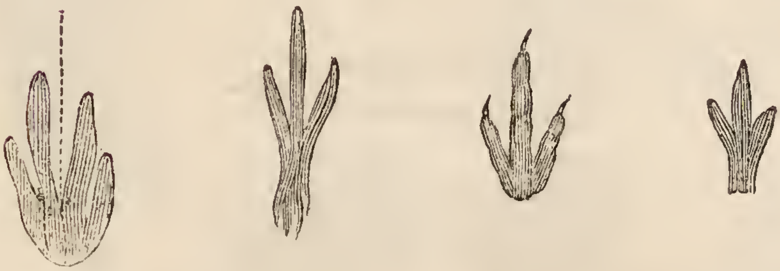
No. 12.



Ornithichnites Ingens. O. Giganteus. O. Tetradactylus.



O. Minimus.



O. Palmatus. O. Clarus. O. Tuberosus. O. Platydactylus.

They consist of the foot-marks of that class of birds called *grallæ*, or waders. Some are of gigantic size, Ornithichnites giganteus measuring seventeen inches in length, including two inches of claws. The foot-marks indicating the ordinary walk of the animal, are four to six feet distant from each other. This bird, then, according to the general proportions of the class, must have been nearly twice the size of the ostrich.

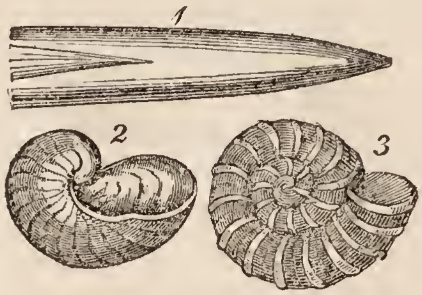
Ornithichnites ingens is from fifteen to sixteen inches in length. O. tuberosus is smaller, and most probably the young of giganteus.

Impressions of animals, most probably of the lizard and tortoise families, have also been discovered in this country, in slabs of new red sandstone in Dumfries-shire.

90. Lias is so named provincially from being in *layers*, or stratified. It is a limestone, of a dark gray or blue colour, mixed with clay of a dull earthy texture, and a conchoidal fracture. It easily splits into layers or slabs. Above is a clay shale. These beds are several hundred feet in thickness. The purest beds contain from 80 to 90 per cent of carbonate of lime — the rest bitumen, alumina, and iron. The lower beds are often of a yellowish white colour. The iron makes the lime procured from lias set under water. A finer kind of lias can be polished, and is used for lithographic stones.

The lias is generally found in horizontal strata, and extends in a waving line through England from Whitby, in Yorkshire, to Lynne in Dorsetshire. It is also prevalent in the eastern side of France, in Ireland, the Hebrides, and partially in Moray and Caithness-shires, in the north of Scotland. The organic remains of the lias consist of ammonites, belemnites, encrenites, pentacrinites, fish, lizards, tortoises, crocodiles, a variety of marine shells, and several fossil plants. The most characteristic shells are the ammonite, belemnite, and gryphite.

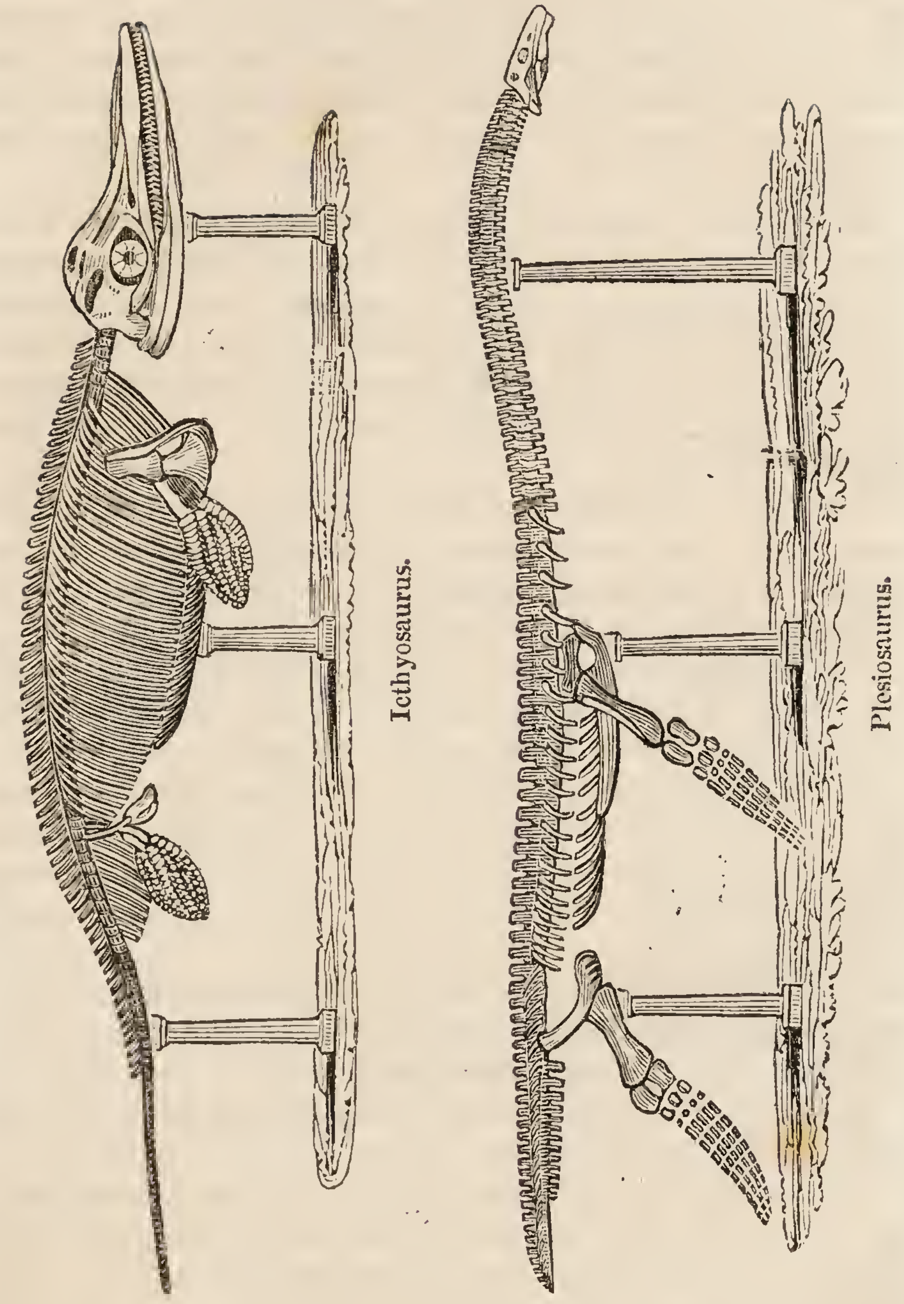
No. 13.



1. Belemnites subconicus.
2. Gryphæa incurva.
3. Ammonites giganteus.

This rock appears to have formed the bottom and shores of bays and estuaries of the sea, for enveloped in it are frequently found portions of bones, and sometimes the entire skeletons of reptiles that had frequented such situations. The most remarkable of these are two animals, which appear from their structure to have been intermediate between fishes and reptiles.

No. 14.



The ichthyosaurus, or fish lizard, appears to have had the long snout of a dolphin, the teeth of a crocodile, the head and breast bone of a lizard, the vertebræ of a shark, and four paddles, similar to those of the whale. The orbit of the eye measures ten inches in breadth.

The plesiosaurus had a back bone like the crocodile, with a neck longer than its whole body, and the head of a lizard.

Some of these animals, of which five different species have been discovered, were twenty feet in length. Their paddles, enabled them to move swiftly through the water; and the long tapering neck is conjectured not only to have allowed the animal to breathe air while its body was concealed in the water, but to stretch its head a considerable way above the surface, and permit it to prey on winged animals flying about in the air.

91. Oolite. Numerous beds of yellowish limestone, alternating with beds of clay, marl sand, and sandstone, have obtained the name of oolite, or roestone, from innumerable small globules, like the roe of a fish, being imbedded in the strata. Sometimes these globules are the size of a pea—hence the term pisiform. The average depth of the oolite strata may be about 1200 feet.

The colour is usually yellowish brown, or ochrey. The stone is of a dull earthy texture, rather friable, and will not polish. The Bath and Portland oolites are used as building stones; but they are not very durable.

The nature of the globules which give the character to this stone is not distinctly ascertained,—it being doubtful whether they are crystalline minerals, or of animal origin.

The organic remains found in the oolite are very numerous, and differ somewhat from the lias below. The different beds of the same series also vary, and have been divided into lower, middle, and upper. The lower beds contain numerous species of the ammonite, the nautilus, belemnite, and other chambered univalve shells, while the unchambered univalves are rare. Numerous bivalve shells, whose animals appear to have existed in shallow seas, are also found in the oolite.

Madripores, millipores, and sponges, compose those beds denominated coral rag.

The remains of fishes and reptiles, like those described in the lias, together with animals of the crocodile genus, indicating the proximity of dry land, are also abundantly common. The subordinate beds of this series are

Bath oolite, containing minute globules and broken shells, cemented by calcareous matter, used as building stone.

Cornbrash, abounding in fossils, and overlying coal beds in Yorkshire and Savoy.

Oxford clay. Between the lower and middle oolites occurs a stratum of bituminous clay, 200 feet thick, containing septaria,

a species of shell, and skeletons of the ichthyosaurus, different from those in the lias.

Middle oolite consists of beds of siliceous and calcareous sandstone, with madripores.

Kimmeridge clay lies between middle and upper oolite. It is bituminous, of a greyish colour, and contains bones of saurian animals.

Upper oolite consists of a calcareo-siliceous freestone, with beds and nodules of flint, called Portland stone, of which Somerset House and other public buildings in London are constructed.

Stonesfield slate is found in the oolite of Oxfordshire. Its organic remains consist of the horny covering of insects —bones of the opossum—a gigantic lizard called the megalosaurus, 40 feet in length, by 12 feet in height—the legs and thigh bones of birds—fishes—crabs—lobsters—marine shells —plants,—and fossil wood.

The oolite formation extends from the sea coast of Dorsetshire, near Bridport, to the southern extremity of the Cleveland Hills, Yorkshire; but is not found in the midland, or north-west counties of England. Professor Sedgwick discovered traces of it in the north-east coast of Scotland, and in the Isle of Sky and Mull. At Solenhofen, Germany, is found the lithographic stone. It resembles the Stonesfield slate in its organic remains. The oolite series is found in Bavaria, Hanover, France, the Alps, Carpathian Mountains, and in Italy.

92. Wealden Beds.—These beds rest above the oolite and under chalk in the wealds of Kent and Sussex. They extend in length to sixty miles, and are from fifteen to twenty miles in breadth. They rest on marine beds, and are covered with marine green sand, but contain remains of fresh water animals and plants exclusively. The beds consist of a blue or brown tenacious clay, sometimes indurated, slatey, and mixed with thin beds of limestone, containing shells of the paludina and cypris, both fresh water animals. The fresh water muscle, helix vivipora, and other shells, are abundant. Also remains of fish, turtles, crocodiles, the plesiosaurus, and megalosaurus, a gigantic species of lizard, approaching to the form of the existing monitor, and supposed by Cuvier to have been seventy feet in length. The teeth and bones of the iguanodon, an herbivorous reptile, somewhat similar to the iguana, a lizard of the West Indies, have also been found in these beds. The teeth resemble the grinders of an animal adapted to feed on vegetable

matters, and many of them are worn flat by attrition. From portions of a huge thigh bone discovered, and measuring twenty-three inches in circumference, the animal to which they have belonged has been conjectured to have been at least sixty to seventy feet in length. It appears also to have been furnished with a horn similar to that of the rhinoceros.

93. CHALK is the last or uppermost of the secondary strata; it lies over the oolite, with green sand between, but sometimes it reposes on the lias and red marl. It extends over the south-eastern and eastern counties of England, north of France. Germany, and north of Europe. It occurs in the north of Ireland, but scarcely a trace of it is to be found in Scotland. The strata formed of it are one thousand feet and upwards in depth.

Shakespeare's Cliff, near Dover, is formed of chalk, but owes a good deal of its sublimity to the imagination of the poet.

> How fearful
> And dizzy 'tis to cast one's eyes so low!
> The crows and choughs, that wing the midway air,
> Shew scarce so gross as beetles: half way down
> Hangs one that gathers samphire — dreadful trade!
> The fishermen, that walk upon the beach,
> Appear like mice; and yon tall anchoring bark
> Diminish'd to her cock—her cock a buoy,
> Almost too small for sight: the murmuring surge
> That on th' unnumber'd idle pebbles chafes
> Cannot be heard so high.

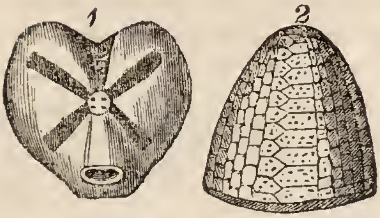
Chalk is almost a pure carbonate of lime—it is, in general, soft and friable, although, sometimes, it is so hard as to be used as a building stone. Numerous nodules composed of siliceous or flinty matter, are diffused through the beds, and generally enclose some animal or vegetable matter, in such a manner as renders it evident the silex must have originally been in a state of fluid solution in water. These nodules are more frequent in the lower than upper chalk beds.

Chalk appears to have been formed at the bottom of the sea, probably by the wearing down of calcareous rocks to a fine sand or powder, or by a sudden precipitation from some chemical solution. Its organic remains are exclusively marine.

Green sand, on which the chalk beds rest, is a loose siliceous sand mixed with green earth; it contains siliceous concretions, hornstone, and flint. Its general thickness is four hundred feet.

The organic remains most frequent in chalk, are,—the spatangus, and echinite, or sea urchin.

No. 15.



1. Spatangus Cor. 2. Galerites albogalerus.

Several chambered shells, as scaphites, hamites, turrelites, baculites, are peculiar to chalk. Ammonites, bellemnites, nautilites, zoophytes, sponges, and bivalve shells, are numerous. Spiral univalves are more rare — Saurian reptiles are also rare—marine vegetables or fuci, and fossil wood, are not uncommon.

Chalk sometimes contains a considerable intermixture of magnesia, and this imparts to it a brown spotted appearance.

The stratification of chalk beds is not, in general, very distinct, which may be owing to the soft yielding nature of the mass, admitting of the several layers passing indiscriminately into each other.

SECTION VIII.

TERTIARY OR SUPRACRETACEOUS STRATA.

94. Under this head is included all those formations which appear to have been deposited after the chalk. Many of these deposits are partial and local, such as that around Paris, the London clay, and portions of the countries of Italy and Sicily.

The tertiary beds are formed of various materials,—of lime, gypsum, sand, clay, and earthy alluvium ; and marine and fresh water beds are frequently alternated and mingled with each other in a confused and irregular manner, often indicating the effects of currents of water, the overflowing of the ocean, and estuaries of rivers running into the sea.

Mr Lyell has endeavoured to trace a progressive approach in the organic remains of the tertiary strata to the present state of things existing on the earth. He has, therefore, divided them into three groups, corresponding to three different epochs, and designated them thus :—1st, The *eocene*, the period immediately succeeding the chalk. 2d, The *miocene*, or less new. 3d, The

pliocene, or more recent period. To the first, belong the Paris basin, London clay, and Isle of Wight; to the second, the marls of Jouraini, the basin of the Geronde, and a portion of the Subapennines near Turin; to the third, the remainder of the Subapennines, a lower range of the mountains of the same name extending through Italy, the tertiary strata of Sicily, and part of the Morea.

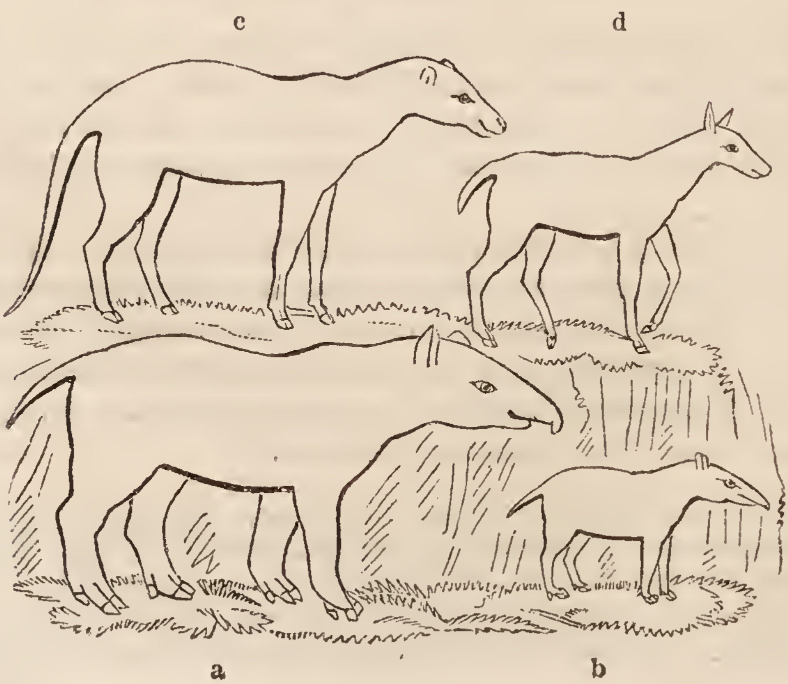
95. Paris Basin. — This formation is local, being confined to the environs of Paris, while the surrounding country is chalk. It consists of five layers.

1st, Or lowermost layer, composed of plastic clay—a fresh water formation.
2d, First marine bed—shells, &c.
3d, Fresh water—gypseous marl, with bones.
4th, Second marine formation—marl and sandstone.
5th, Fresh water limestone, with fresh water shells—the external covering, alluvial soil and peat.

The celebrated Cuvier was the first to examine this deposit, and, after the labour of years, to give to the public a most interesting account of the singular remains of animals of extinct and unknown genera and species which it contains.

Of these, seventy-eight individuals have been described. Fifteen belong to the crocodile and lizard class of reptiles, and to birds; sixty-three to mammalia. Of the mammalian quadrupeds, thirty-two are hoofed animals, non-ruminating; twelve are ruminating animals; seven are of the rodentia, or gnawers; eight are carnivorous; two are toothless animals of the sloth genus; and two are amphibious.

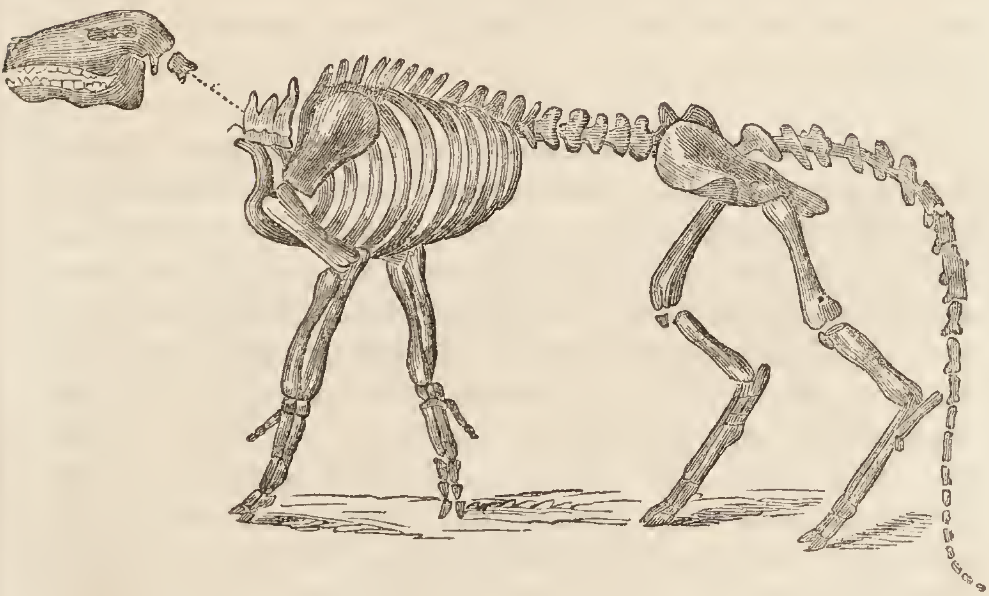
No. 16.



The outlines in this cut exhibit the supposed form of some of these animals, according to the indications of their skeletons — *a* Paleotherium Magnum. *b* Minimum. *c* Anoplotherium. The Paleotherium (*earliest animal*) appears to bear some resemblance to the Tapir—its skeleton is equal in size to that of the horse, but its form is heavy, and its legs thick and short. It had three toes on each foot, is supposed to have inhabited marshy ground, and fed on the roots and stems of juicy vegetables. One of the species, however, appears to have had the light and agile figure of the antelope, and is supposed to have browsed on aromatic plants, or the buds of young trees. "Probably," says Cuvier, "it was a timid animal, with large moveable ears like those of the deer, which could apprise it of the least danger. Doubtless, its skin was covered with short hair; and we only want to know its colour in order to paint it as it formerly lived in the country where, after so many ages, its bones have been dug up.

The Paleotherium Minimum *b*, was not larger than a hare.

No. 17.



Anoplotherium.

The anoplotherium *c*, No. 16, or animal without defensive teeth, has two very distinctive characters. The feet have only two toes, which are separated the whole length of the foot; the teeth, of which there are six incisive, one canine, and six molar, in each jaw, are all ranged close to each other

without any interval, which is the case with no other known quadruped. Its height was about that of a boar.

Besides quadrupeds, nine or ten species of birds have been discovered in the Paris gypsum.

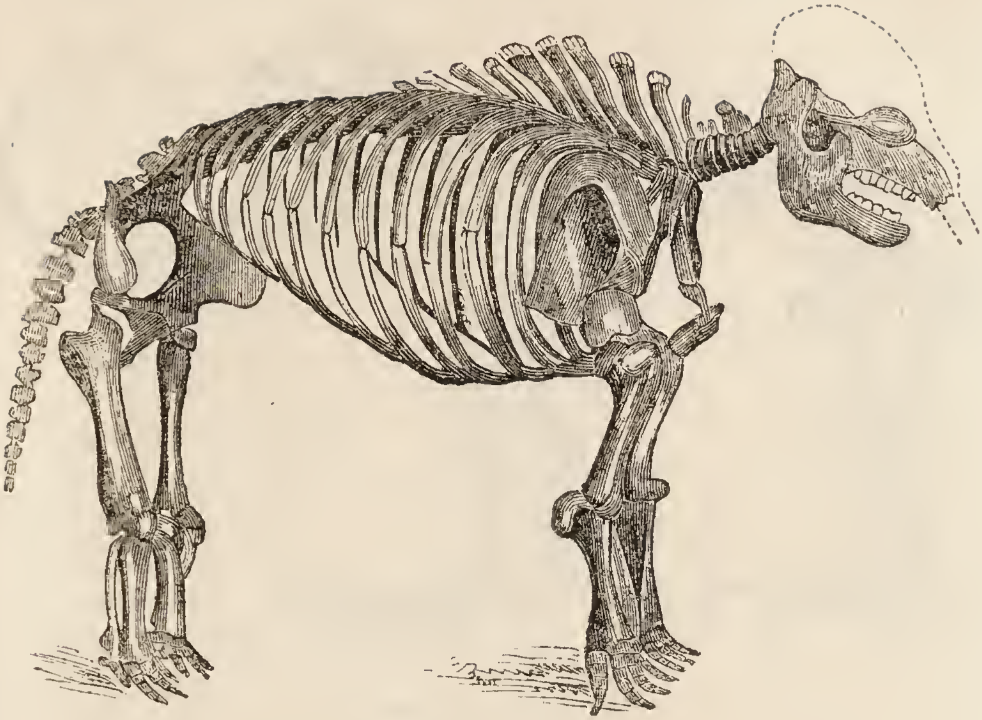
VERTEBRATED ANIMALS IN GYPSUM OF PARIS BASIN.

Pachydermata,	Paleotherium—anoplotherium —cheropotamus—adapis.	Extinct species of extinct genera.
Carnivora,	Bat — wolf—fox—large distinct species—coatis, large, now native of South America — racoon, North America — genette, viverri, in South of Europe and Cape of Good Hope.	
Marsupialia,—Opossum, small, North and South America.		
Rodentia,—Dormouse, two small species—squirrel.		
Birds,	Nine or ten species of the following genera :— Buzzard — owl — quail — woodcock — sea lark — curlew — pelican.	
Reptiles,—Fresh water tortoise—trionyx—emys—crocodile.		
Fishes,—Seven extinct species of extinct genera.		

96. In various parts of the globe the remains of extinct animals have been found, in the tertiary strata and in the diluvian clay and gravel close to the surface of the existing soil. One of the most common, is the mammoth or fossil elephant.

The Mammoth.—This animal must have existed in herds of hundreds or thousands. According to Pallas, there is scarcely a river, from the Don to the extremity of the promontory Tchuskoinoza, in the banks of which the bones of the mammoth are not most abundant. Two large islands near the mouth of the river Indigerska are said to be entirely composed of the bones of this animal, intermixed with ice and sand. The tusks are so perfect that they are dug out for ivory. With the bones of the mammoth are intermixed those of the elk, rhinoceros, and other quadrupeds. Bones and teeth of the mammoth are not unfrequently found in England, in beds of gravel and clay, and in caverns. They have also been found mingled with bones of other quadrupeds in France, Germany, and the Himmala mountains of Asia. The mammoth was equal in size, and bears a general resemblance to the Elephant, yet has many peculiarities of structure which imply a distinct species.

No. 18.



Mastodon Maximus.

The mastodon had more pointed grinders than the mammoth. Entire skeletons and numerous teeth of this fossil elephant have been found at the great salt lick on the Ohio North America, and in Virginia. These remains are in the mud, a few feet from the surface of the soil, and not only bones but portions of the fleshy parts, and the remains of half digested vegetables, consisting of leaves of a shrub still growing in the country, accumulated in little heaps corresponding to the situation of the stomach, leave little doubt of their relation to the more perfectly preserved skeletons among which they lie.

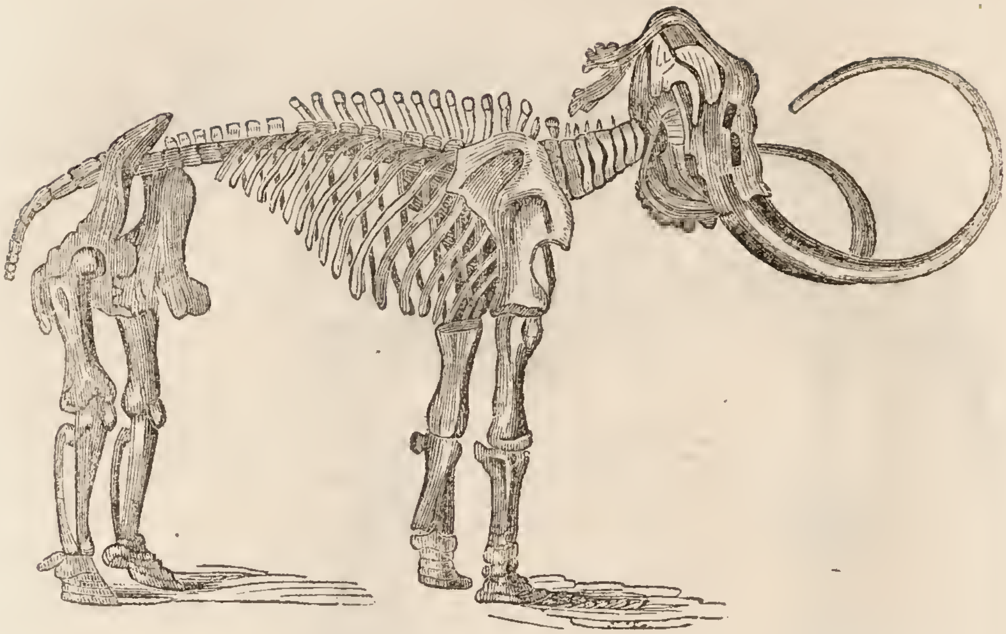
The Indians have a tradition and a belief, that this animal still exists beyond the mountains, and these relics render it probable that the animal may not have been long extinct.

An almost perfect skeleton of the mastodon is preserved in the museum of Philadelphia, of which the above is a sketch. The upper bones of the head are awanting, but the dotted line represents the form of the skull as restored by Cuvier.

The shortness of the neck, and the termination of the muzzle, indicate the existence of a trunk or proboscis in the entire animal.

Six species of the mastodon have been enumerated.

No. 19.



Siberian Elephant.

The Siberian elephant, so called because found in an iceberg in that country, differs from the existing species in the form of its head, and the greater length and greater curvature of its tusks. Cuvier thus describes the state in which this inhabitant of a former world was displayed to view, after an entombment of thousands of years.

"In the year 1799, a Tungusian fisherman observed a strange shapeless mass projecting from an ice bank, near the mouth of a river in the north of Siberia, the nature of which he did not understand, and which was so high in the bank as to be beyond his reach. Next summer he observed the same object, which was then rather more disengaged, but he was still unable to conceive what it was. Towards the end of the following summer, in 1801, he could distinctly see that it was the frozen carcass of an enormous animal, the entire flank of which, and one of its tusks, had become disengaged from the ice. In consequence of the ice beginning to melt earlier, and to a greater degree than usual, in 1803, the fifth year after the discovery, the enormous carcass became entirely disengaged, and fell down from the ice crag, on a sand bank, forming part of the coast of the Arctic Ocean. In the month of March of that year, the Tungusian carried away the two tusks, and at this time a drawing of the animal was made. Two years after-

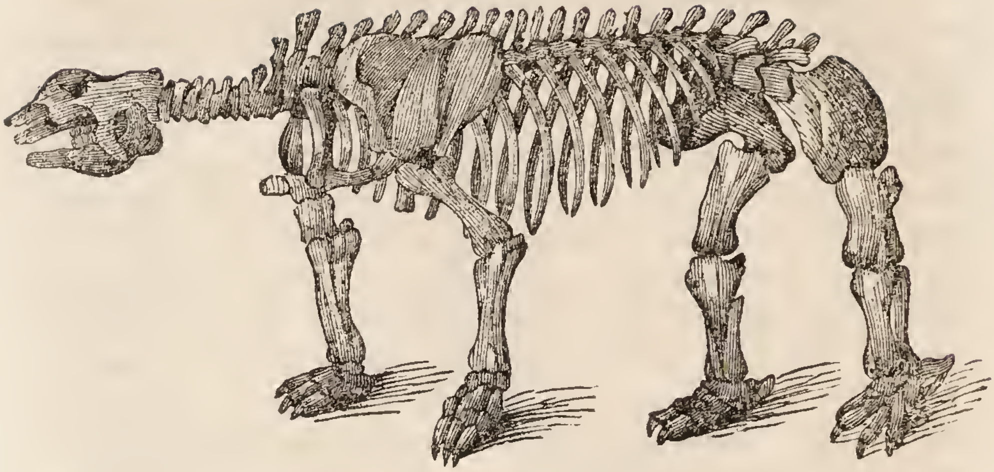
wards (in 1806) Mr Adams examined the animal, which still remained on the sand bank on which it had fallen from the ice, but its body was then greatly mutilated. The Jakuts of the neighbourhood had taken away considerable quantities of its flesh to feed their dogs, and the white bears had also feasted on the carcass, yet the skeleton remained quite entire, with the exception of one fore leg. The extremities were kept together by part of the skin and ligaments. The head was covered by the dried skin, and the pupils of the eyes were still distinguishable. The brain also remained within the skull, but a good deal shrunk and dried, and one of the ears was in excellent preservation, still retaining a tuft of strong bristly hair. The animal was a male, and had a long mane on its neck. The skin was extremely thick and heavy, and as much of it remained as required the exertion of ten men to carry away. More than thirty pounds of the hair and bristles of this animal were gathered from the wet sand. Part of the hair was black, part of a reddish brown, of three kinds, — a soft flexible — a firmer bristly, in length a foot or more — and a shorter fur. The Indian elephant of the present day has scarcely a bristle in its skin. Some hairy elephants, however, exist in the northern mountains of Hindostan; and this fossil[1] animal would appear to have been a distinct species, fitted to inhabit the regions of the north. Captain Beechy has since examined icebergs in Behring's Straits, North America, containing fossil bones, and is of opinion that these bones are contained in alluvial banks, which have been afterwards frozen by accumulated external coats of ice. May it not be probable that this was the case with the Siberian elephant?

[1] Circumstances of this kind are exceedingly interesting, as illustrative of the change of climate which has taken place on the surface of the globe, a subject which will be treated of in a subsequent section.

No. 20.

A molar, or pointed grinding tooth of the Mastodon.

No. 21.

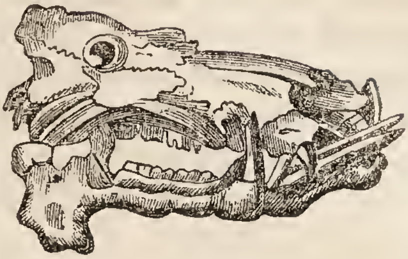


Megatherium.

A complete skeleton of this animal was found in the alluvial soil near Buenos Ayres, and sent to Madrid. Afterwards another was discovered near Lima, and a third in Paraguay. The Madrid skeleton is fourteen feet long, and seven high. It is one of the largest and most massive skeletons hitherto found, and compared even to the mammoth and rhinoceros, appears rude and unshapely in the extreme. Cuvier supposes it to have been intermediate between the sloth and ant-eater, and Buckland conjectures that it must have been covered with a coat of mail like the armadillo, from portions of such a scaley panoply having been found along with the bones. It does not by any means seem calculated for quick motion. Its teeth indicate that it fed on vegetable matter, probably the roots of plants, its long and enormous claws being adapted for tearing up such roots from the soil.

The gigantic Fossil Elk. — Skeletons of this animal have been found in Ireland, in the Isle of Man, in England, France, and Germany. A complete skeleton from the Isle of Man is in the Edinburgh Museum. It is six feet high, and nine feet in length. It was found in a marl bed, containing shells, and stems and roots of trees.

No. 22.



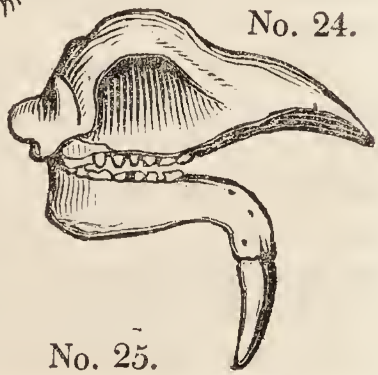
Head of Hippopotamus.

Skeletons of two species of Hippopotamus (the major and minor) are also frequent amid the diluvial fossils. The only living species of this animal is at present confined to the rivers of Africa, while the fossil remains are found dispersed over Europe and Asia.

No. 23.

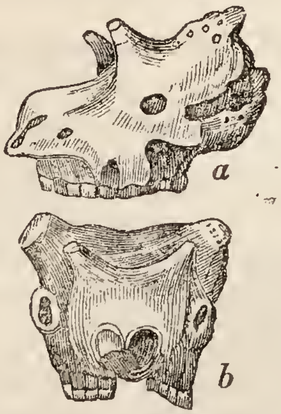
The Pterodactyle. (23.)—Skeletons of an animal which has received this name have been discovered of so anomalous a nature, as to leave it doubtful whether the creature belonged to the class of birds, amphibious animals, or fishes. By some it has been thought analogous to the bat.

No. 24.



The Dinotherium. (24.)—Portions of the skeleton, and a nearly entire head of a large animal, have been discovered in the province of Hesse Darmstadt. The lower jaw is curved downwards, and is furnished with two large tusks. The animal is supposed to have resembled the whale or dugong, and may have been eighteen feet long, or even have equalled the largest of the cetacea.

No. 25.



a, side view—*b*, front view.

The Sivatherium. (25.)—Among several fossil remains of new species of animals discovered in the lower range of the Himmala Mountains in India, a nearly entire head was found in a mass of stone, to which this name has been given. The animal appears to have been intermediate between the Ruminantia and Pachydermata; has had four horns, one placed immediately above each eye; and, from the structure of the snout, it must have been furnished with a proboscis. The head measures eighteen inches in length, by twenty-two in breadth.

97. Bone Caves.— Several caves have been discovered where the mud or diluvium forming the bottom has been strewed with bones. The Kirkdale cave, Yorkshire, extending two hundred feet in a bed of limestone, as described by Dr Buckland, contained an immense number of bones, which belonged to the following animals:—the hyena, tiger, bear, wolf, fox, weasel, elephant, rhinoceros, hippopotamus, ox, deer, raven, pigeon, and several others.

These bones were almost all broken into fragments, and seemed to Dr Buckland as if they had been crunched by the teeth of carnivorous animals. He conjectures that the cave may have been the den of hyenas, and that the bones were those of animals on which they had preyed. But this explanation is liable to many objections. Others have endeavoured to account for the collection, by supposing that the carcasses of various animals, accumulated by some current or eddy of the ocean or rivers, have been swept in, and deposited in the cave; or, that the animals, taking refuge from some dire catastrophe of nature, have there been entombed; or that the whole having been shut up together alive, that the carnivorous hyenas have preyed upon the herbivorous animals, and, at last, on each other.

Caves of a similar nature are found at Gaylenruth, in Germany, enclosing bones of the larger quadrupeds in such a way as to leave no obvious means by which such animals could have entered them alive, and, therefore, affording a presumption that the calcareous matter of the caves, in a state of solution, may have enveloped the animals at the time of their destruction, and, afterwards hardening around them, produced this natural entombment.

List of Fossil Mammalia hitherto identified in the more superficial clay or gravel, forming the ancient diluvium.

Elephant, or Mammoth; very common in various parts of Europe, north of Asia, North and South America.
Mastodon Maximus; North America.
———, smaller species; Europe, North and South America.
Hippopotamus, Major, Minor; England, Europe.
Rhinoceros; four species; common in Europe.
Elasmotherium; Siberia.
Tapir; Europe.
Cervus; Gigantic Stag; Ireland, Europe; several species.
Bos. Urus; Buffalo or Bison genus; North America.
Auroch; Europe.
Trogontherium; Sea of Argos.
Megalonix; America.

Megatherium ; South America.
Hyena ; Europe.
Ursus, Bear ; Europe, America.
Equus, Horse ; common ; Europe, America.
Dinotherium ; Germany.
Sivatherium ; Himmala Mountains.

Fossil Animals found in Sand, in Miocene, or Second Period of Tertiary Formations, at Darmstadt.

Dinotherium,	2 species, herbivorous ; 15 to 18 feet long.
Tapir,	2 species.
Chalicotherium.	2 species ; allied to Tapir.
Rhinoceros,	2 species.
Tetrucauloden,	allied to Mastodon.
Hippotherium,	allied to Horse.
Sus,	3 species ; allied to Hog.
Felis,	4 species of large Cats, like Lion.
Machairodus,	1 species ; allied to Bear.
Gulo,	allied to Glutton.
Agnotherium,	Dog as large as Lion.

Among all these remains of animals, no vestiges of the monkey tribe have been discovered, until lately, in the department of Gers, in France, a single jaw bone of one of these animals was found among other skeletons of extinct quadrupeds.

98. No traces of man or his works have hitherto been discovered in any of the strata, which can distinctly claim a remote antiquity, corresponding to that of the extinct species of quadrupeds. Supposing that man was cotemporary with the animals of the older strata, there are several causes which would account for the absence of all trace of him.

In the early condition of man, his numbers must have been infinitely small, compared to the rest of the animal creation, and, therefore, the chance of the discovery of his remains is as one to many thousands.

Man, too, was long confined to a certain limited spot on the earth's surface, while the animal creation, it is to be presumed, was universally diffused ; so that the extensive forests and wild savannahs swarmed with existences, although no eye of intelligence might be there to behold their motions.

Those regions most minutely examined by geologists, such as England, France, and Germany, were evidently long under the ocean, and must have become habitable, first, to certain animals, and then to man, at a comparatively late period of the earth's history.

Several instances have occurred where human bones were found in caves and imbedded in soft rocks, but these rocks present every appearance of having been consolidated at a

comparatively recent date. A human skeleton, well preserved, with the exception of the head, was found in a rock of this kind, in the Island of Guadaloupe, and is now deposited in the British Museum. Bones of the human species have been found in caves of mountain limestone, in South Wales, in the Mendip hills in England, in the department of L'Aude, at the foot of the Pyrenees, and in other localties, accompanied by the bones of extinct and recent animals.

A cave of this description, of tertiary limestone, in the department of Gard, near the mouth of the Rhone, is said to contain, in the soft mud or diluvium which occupies its bottom, a number of bones of the hyena, rhinoceros, and stag, exactly in the same condition as those in the Kirkdale cave described by Dr Buckland. With these, human bones are also sparingly mingled, presenting exactly the same appearance as the fossil species. Along with the bones, are found fragments of pottery of a very rude construction.

There can be no doubt that many races of animals which once lived on the earth are now extinct. Their history and fate form an interesting page in the volume of life. They have been the pioneers of nature. Myriads of fish and shell animals swarmed in the vast oceans ; strange reptiles in the bays and shallows. Mastodons, elephants, megatheriums, tapirs, in herds of hundreds and thousands, occupied the wide plains and savannahs, and broused the herbs, and roamed the jungles, animating the lone solitudes where yet there was no human eye to contemplate their forms or intrude upon their domains. All are long since perished. Whether the races became at once extinct in the awful catastrophe which overwhelmed and remodelled the world ; or whether they may not have rather gradually fallen and retired before the resistless spread of the human race, for such occurrences are going on even now, is to us a mystery. Some animals, even within the page of history, have been totally extirpated from extensive ranges of country, and others entirely blotted from the earth. A remarkable example of this kind is afforded by the dodo, a bird which was common three hundred years ago, in the Mauritius, but whose race is now entirely destroyed. Such extirpations are still in gradual progress ; so that, at last, as man advances in civilization, and extends his numbers still wider and wider, the lion and tiger, and other animals of prey, may only become known to posterity as matter of history, as beings that once occupied the soil like the mastodon of the Ohio.

SECTION IX.

CHANGES NOW TAKING PLACE ON THE EARTH'S SURFACE.

99. The solid surface of the earth is gradually undergoing changes and modifications. The action of the atmosphere, of rain, rivers, and the ocean, present mechanical forces by which the solid rocks and looser soil are continually washed away from the higher grounds, and accumulated in the hollows or in the depths of the ocean. This is termed disintegration, and the fragmentary portions of rocks are called debris.

Even the hardest rocks are thus acted upon. Huge masses of granite and trap are thus seen in isolated situations, worn down by the slow but incessant agency of the air and moisture, while the particles, thus formed, exactly resemble the sand of the sea shore, which, indeed, has been produced by similar processes. Rivers, too, especially when swelled into torrents by excessive rains, not only sweep away the looser clay and soil by which their waters are rendered thick and turbid, but also wear down the hard rocks, and carry their fragments to great distances.

When large rivers flow into the sea, deltas, or triangular masses of sand or mud, are thus accumulated, and trees, and shrubs, getting entangled among such materials in the course of time, form islands of considerable extent. This is the case at the mouth of the Mississippi, the Ganges, and other rivers.

The quantity of mud deposited by the Ganges, has been estimated by Mr Everest, to amount annually to upwards of six thousand millions of cubic feet,—a mass of matter which would exceed in weight sixty of the pyramids of Egypt. The delta of this river extends two hundred and twenty miles upwards from the sea.

The ocean, too, is in many places making encroachments upon the land, especially where opposed by high and rocky strata. These strata are continually acted upon by the impetus of the waves and the chemical action of the saline particles, and are thus suffering a slow but incessant diminution. When, as not unfrequently happens, the lowermost beds of such strata are softer than the upper, they yield more readily to the opposing force, and thus the higher rocks are undermined. In general, however, the sea has worn for itself a gradually sloping beach ; the sand and gravel thus form a protection to the rocks beneath, and the gradual shallowing of the water diminishes

the impetus of the waves. Indeed, in many situations, by the agency of the wind and high tides, such beaches rather increase, instead of suffering a diminution.

Inland lakes, which terminate in a river course, by the wearing down of their banks, may suddenly be drained, and thus may carry away considerable portions of soil in their overwhelming torrents ; and the denudation of whole districts by convulsive eruptions of the sea will be afterwards alluded to.

The general tendency of these acting forces, then, is to wear down the materials of the globe and to fill up the ocean. This is a process incessantly going on to a certain extent, but it is checked by many other counteracting agencies.

100. Vegetation is one means by which the wearing down of the surface is prevented.

We may suppose, when first the angular and barren rocks were projected from the depths of the ocean, that vegetation overspread the surface by slow degrees : first of all, the simple lichens would cling to the surface of the rocks by their glutinous and adhesive seeds ; these would spread out, and decaying and mingling with fragments of rocks incessantly giving way to the action of the elements, the hollows would gradually be filled up with soil ; this soil would in time be covered with mosses and other cryptogamic plants, till at last the whole would be covered by a thick verdure. This verdure, decaying and renewing every year, would not only add to the soil, but form a secure protection to the rock below. The debris of the rocks and mountains, too, by accumulating, at last form a deep mass of fragments which effectually protect the parent rocks from farther decay.

101. The animal creation assist in compensating the wasting effects of the elements. A species of zoophytes fix themselves upon projecting rocks in the ocean, and secreting lime from its waters build up the arborescent corals, which in many seas form reefs of thousands of miles in length. These coral reefs gradually entangle the floating sea weed, and trees and plants, from the neighbouring continents, and thus islands of considerable extent are formed. Innumerable islands of this kind are found in the South Seas, and have been described in their various stages of formation, by Captain Beechy, in his voyage to the Pacific.

No. 26.

Many of these appear circular, and are, in fact, the hollow craters of extinct volcanoes. The coral zoophytes have first attached themselves to the elevated edges of these craters, and raised them to a level with the sea. At low water, these reefs entangle floating vegetation, till in process of time a soil for the growth of shrubs and palms has accumulated. A lake or marsh for a time forms the centre, but this, too, is gradually filled up with soil, and at last a little island rises out of the waves. Numerous small islands then gradually join to form a large one, and probably still farther elevations take place from renewed volcanic action from below. Beds of limestone, of considerable thickness, which have been entirely formed by the agency of those minute animals, are to be met with in almost all the South Sea islands, thus affording an illustration of the manner in which the coralline limestone found in the older strata in many parts of the old world, has been produced.

102. Notwithstanding the powers of these various agencies, the actual changes which have taken place in the old world since the earliest indications of tradition or historical record, must have been very partial, and on the whole insignificant. The ancient boundaries of islands and continents, and the situations of particular places, as mentioned in the records of history for thousands of years, still remain essentially the same to the present day. The monuments of Thebes, the famous tower of Pharos, and the sea bath of Eunoste, cut in a solid rock of the Egyptian shore, are yet remaining. Sylla and Charybdis are still rocks hazardous to navigators, and the Isthmus of Corinth is the same apparently as it was described three thousand years ago.

103. Peat. Accumulations of vegetable matter sometimes take place on the earth's surface, forming a depth of 10 to 100 feet and upwards, and extending sometimes over fifty miles of country. These are called peat mosses. Peat is formed of various vegetables, as lichens, moss, reeds, grasses, heaths, and shrubs, but most commonly of a species of moss called

*Sphagnum palustre.** This plant grows to the height of five or six inches, when its lower stem begins to decay, and forms a soil from which the upper portion of the plant continues to vegetate. Thus, a successive decay and vegetation of the same stem goes on for many years, till a large accumulation of spongy vegetable mould is formed, filling up the hollows between mountains, or ranging over marshy valleys. The formation of peat is peculiar to cold, moist, and temperate regions. In hot climates, dead vegetable matter is almost instantaneously decomposed or reduced to its elementary principles, but in colder regions a partial decomposition only takes place. Peat consists of from sixty to ninety parts in the hundred of inflammable matter, resembling that of coal; the rest is earth derived from an admixture of the soil in which it has been produced.

Not unfrequently large trunks and roots of trees are found amid peat, and, indeed, whole forests have gradually fallen down and become converted into this substance.

In the year 1651, when the Earl of Cromarty was nineteen years old, in travelling over the parish of Lochbrun, he passed by a very high hill, which rose in a gradual acclivity from the sea. At less than half a mile up from the sea, there is a plain about half a mile round, and from it the hill rises in a constant steepness for more than a mile in ascent. This little plain was at that time completely covered with a firm standing wood, which was so very old that not only the trees had no green leaves, but the bark was quite thrown off, which the old countrymen who were with his lordship said was the universal manner in which fir woods terminated, and that in twenty or thirty years after, the trees would commonly cast themselves up from the roots, and so lie in heaps till the people cut and carried them away. About fifteen years afterwards, his lordship had occasion to come the same way, and observed that there was not a tree, nor even a single root, of all the old wood remaining; but instead of them, the whole bounds where the wood had stood was all over a flat green ground covered with a plain green moss. He was told that nobody had been at the trouble to carry away the trees, but that being all overturned from their roots by the winds, the moisture from the high grounds stagnated among them, and they had in consequence been covered

* The most common plants composing peat moss are, sphagnum palustre, hypnum cuspidatum, byrum hypnoides, lichen rangeferinus, erica vulgaris, Juncœ, &c.

over by the green moss; the place was so soft and spongy, that his lordship, in attempting to pass over, sunk up to the shoulders. Before the year 1699, (in the space of forty-eight years,) the whole piece of ground was converted into a moss, and the country people were digging peats out of it. At first they were soft and spongy, but gradually improved to the ordinary quality of peat.

Extensive peat mosses are found in England, Ireland, Scotland, and in many parts of the north of Europe. They exist partially in the southern countries of Europe, as France, Spain, and Portugal, but disappear as we approach towards the torrid zone.

Large oaks, firs, and other trees, are often dug out of mosses. An oak dug out of Hatfield Moss measured one hundred feet in length, which exceeds in size any tree at present growing in that part of the country. Various animals, and even human beings, have been found, in a wonderful state of preservation, in mosses, after having lain there for many centuries, the tannin of the wood having the property of preserving animal substance from decay.

In 1747, the body of a woman was dug out of a moss in Lincolnshire, and from the construction of the iron sandals found on her feet, she must have been buried there since a period of remote antiquity; her nails, hair, and skin were in a wonderful state of preservation. Another body of a man, in a state of complete preservation, was dug out of a morass on the estates of Earl Moira in Ireland. It was clothed in a garment of hair, and as such garments were worn before the introduction of woollen cloth, the antiquity of the body must have been great. In the year 1674, two bodies were found in a moss in Derbyshire, after they had lain there for twenty-eight years; the colour of their skin was fair and natural, their flesh soft as that of persons newly dead. At the battle of Solway, in 1542, when the Scottish army was routed, a troop of horse in their flight plunged into a morass, which instantly closed upon them; this story was traditional, but in confirmation of the fact, some years ago, a full armed trooper and his horse were discovered in this identical place.

Peat moss, from its porous spongy nature, after having been soaked with moisture, frequently bursts and overwhelms the neighbouring country.

SECTION X.

DILUVIUM — ALLUVIUM — RECENT SOIL.

104. Over the surface of the uppermost strata—of whatever nature that strata may be —there is always found a greater or less accumulation of clay or sand, mixed with rounded fragments of rocks. In hollow valleys, this accumulation sometimes occurs to the depth of twenty or thirty feet ; on the higher grounds it is of less extent.

Such accumulations are termed diluvial, if they indicate a very remote origin ; or alluvial, if of more recent formation. Of the latter kind are accumulations formed by rivers and partial inundations. Both terms, however, are frequently employed as synonymous.

Above this diluvium is found the recent soil, composed of the worn-down particles of the rock of the surrounding country, mixed with the decomposed remains of plants and animals.

105. Boulder Stones. — Detached masses of rocks, varying from a few pounds to several tons in weight, and having their surfaces and sharp edges smoothed down and rounded, evidently by the long continued friction of water, or the action of the air, are of frequent occurrence in the diluvial clay, or strewed over the surface of the soil.

Boulder stones may occur near the masses, from which they have originally been detached, but more generally they are found scattered over districts to a distance ; and various fragments of different rocks will thus be found accumulated and mingled together, sometimes at distances of many hundred miles from their parent rocks. These transportations point out the agency of currents, and immense irruptions of the ocean, passing over the land in particular directions, and with such impetus as to transport these large and ponderous bodies. From the position of these boulders, the direction of such currents may often be distinctly ascertained. Thus, in the valley of Mid-Lothian, fragments from all the hills to the north-westward are found accumulated on the south-eastern shores of Musselburgh. In Switzerland, immense granite blocks from the Alps are found on the limestone strata on the acclivity of Mount Jura ; and fragments from the Scandinavian rocks in the north, occur in great numbers, strewed over the

south of Europe. The same indications of a transport of boulders from north to south is also to be seen on the continent of America.

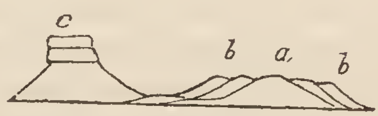
When fragments of rocks have been surrounded with ice, and a thaw has taken place, they have been thus rendered so buoyant as to float in water ; and in this manner, partial transportations of boulders may be accounted for.

Vast accumulations of rolled gravel, and of siliceous sand, are also found filling up many hollows in situations now far removed from the sea, or the action of floods or rivers. Mingled with these are frequently detected the bones of fossil quadrupeds, of birds, and, not unfrequently, the shells of marine and fresh water animals.

All these facts point out the existence, at one period, of an oceanic current, sweeping with great impetuosity in a direction from north to south.

106. Denudation of soil and soft stratifications may be accounted for by the agency of such a current. In many parts of the country, detached portions of strata are found overcapping the summits of mountains and the elevated portions of valleys, which strata are supposed originally to have extended continuously over the country, but the greater part of which has been swept away, leaving the next lowermost strata exposed on the surface.

No. 27.



a, portion of country denuded by strata *b b* being swept away ; *c*, a portion of strata isolated on a mountain top.

SECTION XI.

VOLCANOES — EARTHQUAKES.

107. In various parts of the globe mountains exist, which from their hollow summits emit smoke, heat, and streams of fused earthy matter, called lava. These eruptions are in general only temporary, a cessation, admitting of centuries, intervening between the explosions ; although, in other cases, a slow continued action is constantly going on, with periods of

increased energy, at intervals of months or years. Besides red-hot lava, ashes, mud, water, and gaseous substances, are frequently ejected. The hollow inverted cone, forming the summits of such mountains, which may be compared to a common funnel, is called the crater.

108. Volcanoes are situated, with very few exceptions, near the sea shore. In Europe there are only four great volcanoes,—Etna, in Sicily — Vesuvius, in Italy — Hecla, in Iceland — and Esk Mount, in Jan Mayens Island, besides the minor ones of Stromboli and Iceland. The continent of Asia contains few volcanoes of any note, three or four being enumerated on its eastern shores, and five or six in the peninsula of Kamtschatka. The islands surrounding this mainland, however, contain many large ones. In Africa no known volcanoes exist, although its islands contain several. In the great range of the Andes, stretching along the continent of South America, there are no less than eighty-six volcanoes, in greater or less activity. In this range there are volcanic mountains from thirty to fifty leagues from the sea.

It has been computed that there are at least two hundred and twenty volcanoes at present, or within a very recent period, in a state of activity in the various quarters of the globe.

Volcanoes are called *active* when they continue to emit melted matter, or mud, or vapours, at intervals. *Extinct* volcanoes are those which have ceased to emit such matters within the records of history.

Many mountain cones, exhibiting distinct craters, are visible in different parts of Europe, and the other continents of the world, but which, from all appearance, have ceased from their active state for thousands of years. Of this nature are the mountains of Auvergne, Vivarais and Cevennes in central France; various parts of Italy, Greece, the Canary Islands, Ascension, St Helena, Isle of France, the islands of the great Pacific Ocean, and many others.

Volcanoes are sometimes found isolated, but in general they form connected chains or groups, extending over a considerable space. Thus, the Sicilian group includes Etna, Stromboli, Volcano, and others. The Azores, Canary, and Cape de Verde Islands, form another; and the mountains ranging along the coast of South America constitute a connected chain of volcanic irruption.

Earthquakes, which owe their origin to the same causes, generally precede volcanic eruptions.

First of all are heard subterranean noises, and internal bellowings, accompanied by an undulatory motion of the earth, and frequently the occurrence of large cracks and fissures, and the sinking down of considerable portions of the surface. Then the volcanic mountain bursts forth with volumes of smoke and flame from its crater, followed by streams of liquid lava, which flow down its sides, and often extend, in red-hot currents, over many miles of the surrounding country. Mingled with the vast column of slow ascending smoke, are frequently projected red-hot stones, vapour of water, mud, and light ashes in immense clouds, which, borne along by the wind, are carried sometimes to the distance of several hundred miles. The vapours emitted consist of sulphurous acid gas, nitrogen, carbonic acid and sulphuretted hydrogen, accompanied by common steam. Sulphur is also found in considerable quantities lining the sides and bottom of the crater.

109. Lava, or the melted matter ejected from volcanoes, varies in appearance according to circumstances. It is composed of silica, alumina, potash, lime, magnesia, and oxide of iron in varying proportions.

Tuff or Tufo is a light earthy kind of lava, composed of fragments of scoriæ or cinders agglutinated together.

Stone Tuff is of a reddish brown colour, with orange streaks, caused by interspersed masses of pumice. Its fracture is conchoidal, and it is of sufficient hardness to be employed as a building stone. It is found in abundance in the neigbourhood of Rome.

Granular Tuff is of a blackish brown hue, and is composed of grains slightly agglutinated together. Scales of mica, augite, and leucite are intermixed. When acted on by the air, it crumbles into a brown friable earthy matter.

Pumice is a light porous lava, varying in colour from white to brown and black. It is used in the arts as a polishing stone.

Trachyte resembles the porphyries, having for its basis felspar of a scorified cellular aspect and harsh feel. In this basis are contained crystals of glassy felspar, mica, and hornblende. It varies in colour from a light grey and brown to a black.

Obsidian is a dark coloured substance exactly resembling a mass of common bottle glass.

Pitchstone is nearly of a similar nature, but has less of the vitreous character. Trachyte often assumes the character of the trap rocks already described, and, indeed, the lavas pass by such imperceptible gradations into this series of rocks, that

a distinct line of separation cannot easily be drawn between them.

The trachytes frequently contain veins of jasper, quartz, mica, and felspar, and the other ingredients of granite.

Basaltic columns, too, are not unfrequent among volcanic rocks; dykes intersecting the superincumbent strata are also of common occurrence, and the manner in which the masses of lava have been protruded from below afford an interesting illustration of the formation of the other igneous rocks.

In general, the lava current flows along slowly at the rate of four or five hundred yards per hour. Occasionally, however, the melted current rolls on with a velocity of one thousand eight hundred yards in the same period. The length of the largest stream which has flowed from Vesuvius was fourteen thousand yards.

According to Dolomieu, Etna sent forth a current upwards of ten leagues in length. An eruption of Hecla, in 1783, covered an extent of twenty leagues in length by four in breadth.

Lava cools very slowly, for after the surface has been cooled down and hardened, the interior retains its heat for years. Lavas were seen smoking twenty years after they had been ejected from Etna.

110. The Origin of Volcanoes has given rise to various conjectures. It has been supposed by some that an intense degree of heat exists towards the centre of the earth, and that, from some unknown causes, the equilibrium of this internal fluid being disturbed, it bursts out in certain situations, causing the phenomena of earthquakes and volcanoes. Others, again, have endeavoured to account for the phenomena by the incandescence of inflammable matter contained in the earth's strata, such as bitumen and coal. While a third opinion ascribes the origin of volcanic fire to a chemical combination taking place between the various simple substances of which the globe is composed. It has long been known that a mixture of iron filings and sulphur, moistened with water and buried under the soil, will in a short period unite together, and cause intense heat, and expansion of gaseous matter; but the more recent discoveries of Sir Humphrey Davy have shewn that the elements of many of the earths and alkalies are of such a nature that whenever they come in contact with oxygen, or any compound in which it is contained, they immediately unite with it, evolving intense heat and flame. Thus, a piece of metallic potassium thrown into water, or upon ice, immediately bursts

into flame; and some of the elementary bases of the other earths, as mentioned in Section II. when similarly treated, also exhibit violent chemical action. Sir H. Davy conjectures that the matter of the earth, at a certain depth below the surface, may exist in its simplest form, and that when the water of the ocean, or of internal springs, by any means comes in contact with this matter, such is the violent and extensive production of heat that a volcanic eruption immediately ensues. The fact that volcanic mountains are situated, with very few exceptions, near the sea, and that they frequently emit from their craters water, vapour, and mud, in which are contained fish and other marine products, shews that the presence of water is so far necessary to contribute to the tremendous expansive forces which they exhibit.

111. The earliest record of volcanic eruptions is that in Scripture of the destruction of the cities of Sodom and Gomorrah. And Thucydides mentions an eruption of Etna which must have occurred four hundred and eighty years before the Christian era.

No. 28.

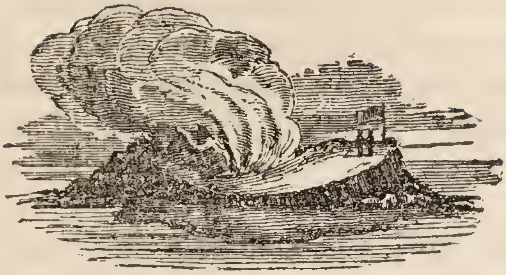
Etna, in the island of Sicily, is about ten thousand feet in height. The principal cone is surrounded by several others of less elevation, which occasionally burst out into action. The crater is about a mile and a half in circumference, and is bounded by black tottering walls, in many places of the height of one thousand five hundred feet. The sides of the mountain are clothed with the most luxuriant vegetation, and forests of pine approach nearly to the summit, till they are checked by the barren snow line, and the black sulphurous crater, whose internal wrath permits no traces of vegetable life to approach its barren and desolate precincts.

Spallanzani ascended to the summit of Mount Etna in 1788, and thus describes the crater,—" The upper edges of the crater,

to judge by the eye, are about a mile and a half in circuit, and form an oval, the longest diameter of which extends from east to west. As they are in several places broken and crumbled away in large fragments, they appear as it were indented, and these indentations are a kind of enormous steps, formed of projecting lavas and scoriæ. The internal sides of the crater are inclined in different angles, in different places. To the west, their declivity is slight; they are more steep to the north, still more so to the east; and to the south-east, on which side I was, they are almost perpendicular, Notwithstanding this irregularity, however, they form a kind of funnel, large at the top and narrow at the bottom, as we usually observe in other craters. The sides appear irregularly rugged, and abound with concretions of an orange colour, which at first I took for sulphur, but afterwards found to be the muriate of ammonia, having been able to gather some pieces of it from the edges of the gulf. The bottom is nearly a horizontal plain, about two-thirds of a mile in circumference. It appears striped with yellow, probably from the above mentioned salt. In this plain, from the place where I stood, a circular aperture was visible, apparently about five poles in diameter, from which issued the largest column of smoke which I had seen before I arrived at the summit of Etna. I shall not mention several streams of smoke which arose like thin clouds from the same bottom and different places in the sides. The principal column, which at its origin might be about twenty feet in diameter, ascended rapidly, in a perpendicular direction while it was within the crater; but when it had risen above the edges, inclined towards the west from the action of a light wind, and when it had risen higher, dilated into an extended but thin volume. This smoke was white, and being impelled to the side opposite that on which I was, did not prevent my seeing within the aperture, in which, I can affirm, I very distinctly perceived a liquid ignited matter, which continually undulated, boiled, and rose and fell, without spreading over the bottom. This certainly was the melted lava which had arisen to that aperture from the bottom of the Etnean gulf.

"Into this, large masses of lava were rolled down from the place where I stood, and when they sunk into the liquid lava, produced a sound similar to what they would have occasioned had they fallen into a thick tenacious paste."

No. 29.



112. Graham Island, which made its appearance near the Lipari Islands, on the coast of Sicily, in 1831, afforded a good illustration of the manner in which islands may be raised by volcanic agency.

At first, a violent agitation was observed on the surface of the ocean, then smoke and vapour burst forth, and in a short period a mass of lava and scoriæ was elevated to the height of eighty feet, and about five hundred paces in length. The materials were, however, too porous to resist the action of the waves, and in the course of a few months, this island disappeared, leaving a shoal in its stead.

In 1811, an island was raised in a similar manner off the Azores, to the height of seven hundred feet above the sea, but it also soon disappeared.

No. 30.

Crater of Vesuvius.

113. Vesuvius, situated on the sea coast of Italy, is also a volcanic mountain of great antiquity. In the seventy-ninth year of the Christian era, a tremendous eruption of this mountain took place, by which the neighbouring cities of Herculaneum and Pompeii were completely destroyed. Scarcely had the inhabitants time to make their escape, when a dense cloud

of ashes enveloped the whole plain. Pliny the elder here lost his life in watching the phenomena of the burning mountain, and the younger Pliny gives a touching narrative of the progress of the devastation which took place. After the lapse of many hundred years, the sites of these cities have been explored, and the furniture, paintings, and works of art, of their former inhabitants, have been found in a state of wonderful preservation.

In the year 1767, this mountain threw out a vast quantity of ashes, mingled with stones, which raised its summit two hundred feet above its former height. The smoke which was continually sent forth was rendered luminous at night by the great light of the flames beneath. On the morning of the 19th October, clouds of smoke were forced, in continual succession, out of the mouth of the volcano, forming a mass like a large pine tree, which was lengthened into an arch, and extended to the island of Caprea, twenty-eight miles distant. This eruption was accompanied by lightning, and by an appearance of meteors like shooting stars.

In 1794, a still more violent explosion took place. It was expected by the inhabitants of the neighbourhood, the crater, or hollow cavity at the top, being nearly filled with water, while that in the wells lower down had subsided. Showers of immense stones were projected to a great height, and ashes were thrown out so plenteously that they fell thick at Tarento, two hundred and fifty miles off. A heavy noxious vapour issued in many places from the earth, and destroyed the fields and vineyards. Another eruption of this mountain took place in 1804; a still greater in 1806; and these eruptions continue to occur at various intervals.

The woodcut represents the crater of Vesuvius as seen by M. De la Beche in 1829. The height of the cliffs of the great crater seemed between 300 and 350 feet — that of the cone in the centre about 90 feet. After the more continued detonations of its action at this period, there was a lull or calm, always succeeded by a violent explosion, throwing up stones to a considerable height, mixed with portions of red-hot lava, which latter fell like lumps of soft paste upon the sides of the small cone. When the smoke or vapour cleared away for a moment, the red-hot liquid lava could be clearly distinguished inside the small crater. At every great explosion, the sides of the little cone appeared to heave considerably. During one of

these paroxysms, the base of the central cone was pierced by the little lava current exhibited in the sketch. The height of the highest summit is about 3890 feet.

114. The island of Iceland owes its entire origin to volcanic action, Mount Heckla being the chief and most elevated crater.

No. 31.

This mountain is about 5000 feet in height. The base is composed of rugged masses of lava and scoriæ, 70 feet in height, and the summit is covered with eternal snow and glaciers. The crater at the top continually emits smoke and lava,—at certain periods, however, with increased violence. It has been in action from the most remote periods of history.

No. 32.

The gysers, or boiling springs of Iceland, are also remarkable. These springs are situated in a valley. From a circular and perpendicular cavern in the earth, a hollow rumbling sound is first heard; then a jet of hot water, accompanied by much steam, is projected to the height of sixty or eighty feet. This flows for a few minutes, and again intermits for a period of some hours. Again the noise is heard, and again the boiling jet of water makes its appearance. The sides of the cavity, and the ground and vegetation around, are covered with a coating of siliceous earth, in the form of chalcedony. These springs have evidently a connection with heated lava below, and, from their periodical action, probably partake of

the character of intermitting springs; or the water may be forced up at intervals by the accumulation and expansive force of steam, confined in a cavity of a peculiar construction.

In the year 1759, in an extensive and fertile plain in the neighbourhood of the city of Mexico, the volcanic mountain Jorullo was suddenly elevated to the height of 1700 feet. In the month of June of that year, a subterranean noise was heard in the plain of Jorullo. This was succeeded by repeated shocks of an earthquake, which continued for sixty days. After the cessation of these, and in a period of tranquillity, on the 28th and 29th September, a horrible subterranean noise again was heard, and a tract of ground from three to four square miles rose up in the shape of a bladder. The affrighted Indians fled to the mountains, and those who there witnessed this great event, assert that flames were seen to issue forth for an extent of more than half a league—that fragments of burning rocks were thrown vast heights—and that, through a dense cloud of ashes, lighted up by volcanic fire, the softened surface of the earth was seen to swell like an agitated sea. Two adjoining rivers precipitated their waters into the burning chasms. Eruptions of mud and strata of clay, enveloping balls of decomposed basalt, were also ejected. Thousands of smaller cones started up around, and continue, along with the principal and central volcano, to emit smoke and lava. Along with this lava are also ejected fragments of primary rocks.

The most tremendous volcanic eruption of late years is that which occurred in the Tomboro Mountain, situated in an island in the Indian Ocean. On Java, distant three hundred miles, the sky was overcast at mid-day with clouds of ashes, the showers of which covered the ground to the depth of several inches, and the report of the repeated explosions was like the sound of thunder. On the island itself thousands of people were destroyed.

115. Earthquakes consist of tremblings and oscillations of the earth, accompanied or preceded by internal noises, and frequently by cracks and fissures of the surface. All parts of the globe are liable to these disturbances, but earthquakes are much more frequent in volcanic countries than in others. Shocks of earthquakes, more or less severe, are of frequent occurrence; and, indeed, taking the whole extent of the globe, it may be said that a week rarely passes in which some portion of it is not convulsed.

Earthquakes generally commence with slight and interrupted

shocks; these gradually increase in violence, are accompanied by a hollow subterranean thunder, till at last they produce a violent undulatory and progressive upheaving of the solid strata. The ocean, too, as well as the land, shares in the agitation, rolling in waves of fifty and sixty feet in height upon the land. The rents in the soil, caused by earthquakes, are of various forms and magnitudes: these have either a straight or winding irregular direction, or they sometimes radiate in all directions from a common centre. During the earthquake at Calabria in 1783, large fissures were formed of half a mile in length, two and a half feet broad, and twenty-five feet deep. In the district of Plaisano, a rent of nearly a mile in length, one hundred and five feet broad, and thirty deep, opened; and in the same district, two gulfs were formed, one hundred feet in depth. In Peru, a rent of two miles in length, and four to five feet in width, was formed by an earthquake in 1746. Sometimes the motion is of a rotatory kind, by which statues and buildings have been partially twisted round. In the year 1772, during an eruption of a volcano in Java, the ground began to sink, and a portion of the mountain, and part of the neighbouring country, estimated to be fifteen miles long, and six miles broad, were swallowed up. During the Lisbon earthquake of 1755, a new quay entirely disappeared. Thousands of the inhabitants had taken shelter on it to be out of the reach of the tottering buildings, when suddenly the quay sank down with its thousands of human beings, and not one of their dead bodies ever floated to the surface. In the year 1692, during an earthquake in Jamaica, a tract of land, about a thousand acres in extent, sank down in less than a minute, the sea immediately occupying its place. On the north side of the same island, several large tracts, with their whole population, were swallowed up, and a lake succeeded, covering at least a thousand acres.

Not unfrequently the surface is elevated instead of being depressed. In 1822, a most extensive commotion of the earth took place in South America, a portion of the country, along the coast of Chili, extending to upwards of one thousand miles, being violently agitated. When the country around Valparaiso was examined on the morning after the shock, it was found that the entire line of coast, for the distance of one hundred miles, was raised above its former level. The area over which this upraising took place, was estimated at one hundred thousand square miles. The rise upon the coast was from two to four

feet; and at the distance of a mile in the interior, it was estimated at from five to seven feet.

116. From the earliest records of antiquity, the world appears to have been convulsed by earthquakes. In the seventeenth year of the Christian era, twelve cities in Asia were destroyed by an earthquake. Two hundred and fifty thousand persons are said to have perished in the earthquake, which happened at Antioch, A.D. 526; and in 1169, another shock destroyed many cities, filled up the valleys of Lebanon, and shattered the basaltic districts of Hauron. In 1759, the cities of Antioch, Balbec, Acre, and Tripoli, were laid in ruins, and 30,000 persons were destroyed.

The memorable earthquake of Lisbon took place in 1755. On the morning of the 1st November, without any previous warning, except a hollow noise like thunder, the ground suddenly began to shake with quick and short vibrations. The whole foundations of the city were disturbed, and many of the principal houses tumbled in an instant to the ground. Then, with a scarcely perceptible pause, the nature of the motion changed, now resembling that of a waggon driven violently over rough stones, which laid in ruins almost every house, church, convent, and public building, with an incredible destruction of the people. It continued for the space of six minutes. At the moment of its beginning, some persons on the Tagus, nearly a mile from the city, heard their boat make a noise as if it had run aground, though then in deep water; and saw, at the same time, houses falling on both sides of the river. Four or five minutes after, the boat made the like noise, caused by another shock, which brought down more houses. The bed of the Tagus was in many places raised to a level with its surface. Ships were drawn from their anchors, and jostled together with great violence, so that the masters did not know whether they were afloat or aground. The large quay to which the people had flocked in crowds for safety or escape, was suddenly submerged, and the whole buried in one gulf. The bar was seen dry from shore to shore. Then suddenly the sea, like a mountain, came rolling in and about Belen Castle, the water rose fifty feet almost in an instant, and had it not been for the great bay opposite the city, which received and spread this vast inundation, the lower part must have been entirely under water. About noon another shock occurred, when the walls of several houses which were yet standing were seen to open from top to bottom more than a

quarter of a yard, but closed again so exactly as to leave scarcely any mark of injury. Many of the largest mountains in Portugal, during the earthquake, were shaken to their foundations, and some of them opened at their summits, rent asunder, and large masses were cast down into the adjacent valleys.

At Oporto, the same calamities occurred exactly at the same hour; the earth shook, and was violently convulsed for seven or eight minutes, accompanied by a rumbling noise like that caused by carriages drawn over rugged stones. Several churches were rent, and the river Douro was observed to burst open in some parts and discharge vast quantities of air; the agitation also was so great in the sea beyond the bar, that it was imagined the air got vent there in a similar manner.

At Cadiz the shock was also violent, and through all parts of Europe, the neighbouring continent of Africa, and even America and the West India Islands, the effects of this tremendous convulsion were distinctly perceptible.

The earthquake that so much affected Calabria in Italy, and destroyed the city of Messina, raged at different periods from 5th February till the 28th March, 1783. Its principal seat was the small town of Oppido, in the neighbourhood of Atramonti, a snow-covered peak of the Appenines. The country for twenty-five miles round this point suffered most severely, but the ravages extended more or less for seventy-two miles. The first shock on the 5th February, in two minutes threw down the greater part of the houses in all the cities, towns, and villages, from the western acclivities of the Appenines in Calabria Ultra to Messina in Sicily, and convulsed the whole surface of the country. Another shock, which took place on the 25th of March, was of nearly equal violence. The granite chain which extends through Calabria from north to south, was but slightly agitated, the principal shocks being propagated with a wave-like motion through the tertiary sands, sandstones, and clays, from west to east. It was remarked that the violence of the shocks was greatest at the line of junction of the granite and tertiary rocks, occasioned probably by the interruption of the undulatory movement of the softer strata by the harder granite. The granite range also prevented the passage of the shocks to the countries on the opposite side of the mountain range. About two hundred towns and villages were destroyed; more than one hundred hills slid down, fell together, dammed up the rivers,

and formed lakes. Numerous rents, often of vast magnitude, were formed. Many subsidences and also upraisings of the ground took place, and the general features of the country were so much changed that they could scarcely be recognized. Thus, in a very short space of time, the whole country was as much changed as if it had been exposed to common influences for many thousand years. The number of human beings that perished was estimated at one hundred thousand, and it was difficult to find even distant relations to succeed to the property of some families.

117. In South America, earthquakes are of frequent occurrence. A most extensive one happened at the Carraccas in 1812. On 12th March, after a long tract of serene dry weather, and without any previous warning, the first shock came on about four in the afternoon, and set the bells a ringing. This was immediately succeeded by a second shock, which caused a waving and rolling motion in the earth, then a subterraneous rumbling noise followed; and there was a third shock, in which the motion was perpendicular, and sometimes horizontal, rolling with a violence which nothing could withstand. The people, in place of flying directly to the open fields, flocked in crowds to the churches, where arrangements had been made for a procession, and the multitudes assembled there were buried beneath the ruins. Two churches 150 feet high, and supported by columns, fell to a mass of rubbish. A public building, containing a regiment of soldiers who were preparing to join the procession, vanished entirely with its inmates. Nine-tenths of the city were destroyed, and most of the remaining houses were uninhabitable. The number of people killed exceeded ten thousand. The clouds of dust which fell cast a horrid gloom over the day, but a serene night succeeded, which formed a melancholy contrast with the destruction on the earth, and with the mangled bodies lying scattered in the ruins. This convulsion extended over a wide range of country, causing much devastation and loss of life, the entire number of persons who perished amounting to sixteen thousand.

118. In Britain repeated shocks of earthquakes have been experienced. In 1580, St Pauls, in London, was injured by a concussion of the earth. In 1777, a slight shock was experienced at Manchester, extending one hundred and forty miles around. In 1795, another shock was felt through several counties of England.

In 1816, an earthquake occurred in the north of Scotland. At Inverness, the steeple of a church was twisted by its effects. Slight shocks are repeatedly experienced at Comrie, in Perthshire.

SECTION XII.

TEMPERATURE.

119. The degree of heat, at the earth's surface, is called its temperature. This temperature varies according to the latitude, being greatest at the equator, and diminishing gradually towards the poles. It varies also in different seasons, increasing in summer, when the sun is most vertical, and decreasing in winter, with the decrease of the sun's altitude.

120. The source of heat thus diffused over the globe is derived from the sun. The land absorbs a greater proportion of this heat than the water, and from thence a portion is communicated to the surrounding air, which, being continually agitated by currents, diffuses this heat generally over the circumference of the globe. Two aërial currents of this nature principally prevail,—a current of heated air rising from the equatorial regions, and proceeding, in directions north and south, towards the poles; while a colder current flows from each pole towards the equator.

The medium temperature at the equator, is about 81° of Fahrenheit's thermometer; at 48° of latitude, on the continent of Europe, the mean temperature is 56°; while, in Melville Island, in the arctic regions, it is 17° below Zero. The medium temperature over the globe has been estimated at 56°.

121. The temperature decreases gradually as we leave the surface of the earth or the level of the ocean, and mount higher in the atmosphere. Hence all mountain ranges and elevated grounds have a lower temperature than the plains below. At a certain height, we come to a region of perpetual congelation where water always freezes, and produces ice and snow. This line varies in height according to latitude. At the equator, it is about 15,577 feet. In latitude 77° it is 767 feet. Hence, some mountains towering to these regions, have their summits continually covered with snow.

From the nature of the plants and animals entombed in the older strata of the globe, it appears evident that the temperate and colder regions must, at one time, have enjoyed a greater

degree of heat than at present. Whether this excess of heat was also superadded to the present torrid regions, is, however, a question not so easily settled.

Indeed, were we to judge from the nature of the organic remains which seem to have a general similarity in many of the strata, both of the tropical and more temperate regions, it would appear as if a more uniform distribution of heat had formerly existed in the different regions of the globe, than at present.

These circumstances have given rise to the speculations regarding central heat, and the change of temperature on the globe.

Whatever the nature of this change may have been, it must have taken place at a very remote period. La Place has demonstrated, that, during the last two thousand years, the temperature could not have varied so much as one-fifth of a degree over the whole globe, otherwise the length of the day would have altered, from the change of the earth's circumference. The length of the day, however, remains unchanged, and if any modifications of temperature have taken place, these must be of a local nature, and owing, perhaps, to draining, clearing, and improving the soil, which, if practised to a great extent over a country, tend in some measure to ameliorate the climate.

122. It has been supposed that there exists a central heat within the globe, and that there has been a gradual cooling down of the surface. In support of this opinion, it is found that springs of water indicate an increase of temperature according to their depth, and that, as we descend in deep mines, the temperature progressively increases, at the rate of one degree for every fifty feet. But this increase, though apparently constant in mines which are in the process of being wrought, varies as to its rate of progression; while in those that have been long abandoned, no such increase of temperature is found to exist. Other objections, too, present themselves to this theory of central heat. The diameter, at the equator, is twenty-six miles more than at the poles. Now, as the surface at the poles is thirteen miles nearer the centre than the equatorial surface, the heat at the former should far exceed that of the latter. The reverse of this, however, is the case. The temperature at the bottom of very deep seas does not equal that of the surface, whereas it would exceed it were the influence of central heat universal, and would be perceptible notwithstanding the law of the ascent of heated fluids.

We have seen, too, that the sun's rays greatly influence the temperature at the surface, so that the equatorial heat should be much greater than it is were it accompanied by a central heat; and the difference of summer over winter temperature in the colder regions should also be less variable, did another source of heat besides that of the sun influence it.

In many extensive tracts of the older strata of the globe, it does not appear evident that there has been a gradual refrigeration of the surface by a progressive gradation of the vegetable and animal remains: on the contrary, there are indications which would point out, in many cases, an abrupt transition from a tropical to the present existing temperature.

123. Mr Lyell proposes to account for the change of temperature by the relative change of the land and sea over considerable portions of the earth's surface.

Geology evidently shews us, that over a vast space of the globe a change has taken place from an ocean-bed to elevated land. Now, as the land has a power of absorbing the sun's rays, superior to that of water, if we suppose that the distribution of land and ocean has been almost reversed on the globe, or that the great continents and islands have ranged along the equatorial regions, instead of stretching from the North Pole to the South, we shall have such an arrangement as would produce the greatest possible degree of heat on the surface from the sun's rays.

By such an arrangement, it is not improbable but that a degree of temperature, approaching to that of tropical, might have been imparted to the latitude of Britain and the northern parts of Europe. That a great degree of heat, however, exists at certain depths within the earth, is evident from the effects of volcanic action. Thus the great volcanic range of the Andes extends five thousand miles along the coast of South America. These volcanoes are, in all probability, connected by one common and enormous source of igneous action. An extensive volcanic chain also exists in the Indian Archipelago, commencing at the Philippine Isles, and extending to Timor, and from thence to Sumatra and Java. In Europe, the volcanoes of Sicily, Italy, and Iceland, form another chain, the extensive connection of which may be presumed, when we call to mind, that the undulations of the celebrated earthquake of Lisbon, in 1755, extended over a space of not less than four thousand miles. From such extensive reservoirs of ignited matter, it is probable that many mines and subterranean

springs may derive their increased temperature, which, after all, may be considered but as local and partial causes when compared to a mass of heated matter, that would form the solid sphere of the globe.

SECTION XIII.

DIVISION OF THE SURFACE INTO CONTINENTS AND ISLANDS.

124. Somewhat more than one-fourth of the surface of the globe consists of dry land; the rest is occupied by the waters of the ocean.

The amount of land is about thirteen times greater on the northern side of the equator than on the southern.

Four great continents form the principal part of the land, — Europe, Asia, and Africa, in the eastern hemisphere, and America in the western. To these may be added New Holland, which is of sufficient extent to form a fifth continent.

A small proportion only of the continents of Asia and Africa extend to the southward of the equator. Europe and Asia extend, in a connected mass, from east to west, and around the arctic extremity of the northern hemisphere. The continent of America, on the other hand, stretches from the north or arctic circle across the equinoctial line to the southern hemisphere.

The space which these continents occupy is as follows: —

	Square miles.
Europe, with its islands, ...	2,243,000
Africa, Madagascar, and Islands, . .	7,464,000
Asia, ...	11,039,000
America, ...	10,000,000
New Holland, ...	2,745,000
Including the ocean, the total superficies of the earth will be, . . .	100,000,000

MOUNTAINS AND VALLEYS.

125. The earth presents everywhere an undulating surface, consisting of mountains and valleys, the whole having a greater or less elevation above the level of the sea.

The only exceptions to this are—the great valley at the foot of the mountains in central Asia, which extends to eighteen

thousand miles square, and is said to be three hundred feet below the level of the ocean; the surface of the Caspian Sea, which is three hundred feet below the ocean level; and the course of the river Volga, one hundred and fifty feet. This inequality of the surface is a necessary provision in its construction, and serves many important uses. Had the earth been one uniform and level plain, the moisture which falls from the clouds could never have been drained off, but would have remained and formed a stagnant morass over the whole surface. Whereas, mountain ranges serve to direct the currents of clouds in discharging their treasures on the earth, and then drain off the moisture by innumerable rills and streams which flow into the plains. The elevation of mountains, too, expose the various strata and metallic veins to the operations of man, shelter him from hurricanes and tempests, and afford a range for the habitats of plants and animals whose natures are adapted for existence in elevated situations.

126. From the preceding descriptions of the formation of igneous rocks, and the elevation of sedimentary strata, it will at once be perceived, that mountains owe their origin to eruptions of matter from below, and that they vary in their structure and figures according to the nature of the particular strata from whence they have been formed.

Mountains generally form chains or ranges, consisting of a succession of elevations, more or less intimately connected together. Sometimes these chains intersect a whole country, as the Grampian range of Scotland, the Alpine and Pyrenean ranges of the continent of Europe, and the great chain of the Andes stretching along the continent of South America.

Mountains are occasionally found single or isolated, and these generally consist of volcanic or trap formations. Dunbarton rock, Stirling Castle rock, the Bass, and several others, are of this isolated nature. Yet these, in reality, belong to the great chain of trap mountains which intersect Scotland.

Mountain chains extend much farther in length than in breadth. Sometimes they are found intersecting the middle of continents and islands; at other times, they stretch along the shores. They give the form and character to a country, and are the centres of elevation from whence the rivers derive their origin; and by whose declivities their waters are conducted in many winding courses to the ocean.

127. Thus, viewing Europe on a general scale, we find that the chain of the Alps and Carpathian Mountains forms its

centre, and its most elevated ground. From each side of this great chain certain rivers take their rise, which, flowing in opposite directions, discharge their waters into different seas.

The Elbe, the Weser, the Rhine, the Loire, flow into the German Ocean; while the Rhone, the Danube, the Po, discharge their currents into the Mediterranean and Black Seas.

The Pyrenean chain separates France from Spain. The Appenines range along the peninsula of Italy. The Uralian mountains separate Europe from Asia, and consist of three parallel chains, running north and south. Mount Hemus connects the Alps with the great Asiatic chain. The Himmala Mountains extend over the south-east of Asia, while another branch, the Altai, take a north-easterly direction.

The most elevated portions of the North American continent are towards the Arctic circle, forming the ranges of the Rocky Mountains, whence the immense rivers of the Ohio, Missouri, and Mississippi, take their origin. In South America, the elevated chain of the Andes occupies the western shores, while the river Amazon, the Plata, and many others, flowing from these high grounds, empty their torrents into the Southern Atlantic Ocean. The Andes form an immense table land, elevated six and eight thousand feet above the level of the sea.

The Himmala Mountains, in the north of India, are the most elevated range on the earth's surface. The highest of these, the Dologer, is 27,677 feet, or five miles and a half, above the level of the sea.

Next to these the Andes of South America are pre-eminent. Nevado de Sorata is 25,250 feet.

No. 33.

Chimborazo. Carquairazo. Cotopaxi.

Chimborazo, formerly reckoned the highest mountain in the world, is 21,440 feet. Cotopaxi is 18,898 feet high. It is the most beautiful of all these colossal summits, presenting the form of a regular and smooth cone, wrapped in a covering of the purest white, which shines in the rays of the sun with a

dazzling splendour, and detaches itself, in the most picturesque manner, from the azure vault of heaven. Its summit forms the crater of a volcano, which is in frequent action; and at night, smoke and flame are often seen rising from it, like a beacon fire, into the regions above. In the course of the last century, it had five great eruptions, and one in 1803. As the incandescent matter ascends, the perpetual snows, which have covered the summit to an almost unfathomable depth, are melted, and rush down in destructive torrents, when its naked and embrowned head is displayed to the astonished inhabitants of the plain. The sound of this volcano is said to have been heard at the distance of six hundred miles. From this, and the other South American craters, are ejected not only the usual volcanic substances, but torrents of boiling water and mud, often containing quantities of dead fishes.

This mountain exhibits strikingly the effect of elevation in modifying climate. The base is situated in the torrid zone, and affords fit shelter for plants and animals of a tropical climate. Mid-way up its sides, the plants and animals of a temperate region are found; while, towards the top, the pines and lichens of the frigid zone can only grow. The summit is enveloped in perpetual snow, while volcanic eruptions not unfrequently blaze from the crater at the top.

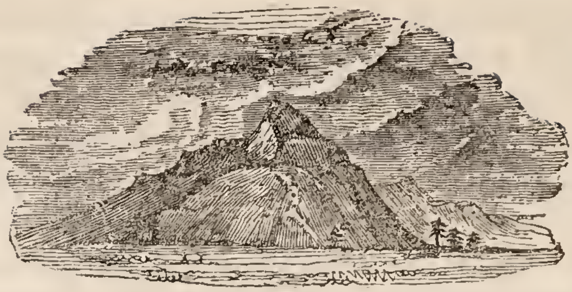
Mount Elias, near the Pacific Ocean, is 18,000 feet in height, and forms the most elevated peak of the North American continent.

The continent of Africa possesses few very elevated positions. Gendar, in Abyssinia, is 8440 feet in height. The Table Mountain of the Cape of Good Hope is 3600 feet.

Mont Blanc, 15,668 feet high, is the most elevated peak of the European Alps. Mont Rosa is 15527 feet. Mont Blanc forms the centre of the great Alpine range. Its summit consists of numerous rugged peaks, clothed with eternal snows and glaciers, while the scenery around its base is the most picturesque in the world. Saussure, the French geologist, was the first who had the daring to reach its summit; and of late years several other travellers have also penetrated to its elevated peaks. North-east of this mountain extends the line of those stupendous Alps which form the Italian boundary,—the Great St Bernard, Mont Rosa, and the Simplon, over which the famous military road has been formed.

The Grampian Mountains extend from the western to the eastern coast of Scotland. The highest of this range is Ben-Macdhui in Aberdeenshire, which is 4400 feet.

No. 34.



Ben Nevis, in Inverness-shire, is 4370 feet in height. This mountain may be said to terminate the range of the Grampians on the west. It is composed of porphyry over-lying gneiss. Being nearly within the range of perpetual congelation, snow always lies in the hollow of its summit, and most commonly its frowning peak is shrouded in the rolling mists of a chill and moist climate.

The Cairngorm Mountains are 4050 feet high, and form the most elevated ridge of the north-western chain of the Grampians. Cairngorm is celebrated for those topaz crystals which bear its name.

128. VALLEYS, or those hollow spaces between mountain ranges, have owed their form to the elevation of the strata on each side. Sometimes they are so narrow as to form only deep passes among the mountains, and such passes appear to have been produced by the rending asunder of the adjacent rocks. The exact similarity of the rocks or strata on each of the sides of these valleys evidently points out this origin.

Valleys, however, of great extent occur where the sides or boundaries are formed by two ranges of separate mountains. Where there is great breadth of valley, the bottom is usually filled up with alluvial deposit to a considerable depth. In narrow valleys again, there is a perpendicular depth and hollow bottom, the overflowing currents having swept away the loose alluvial matter.

In some situations, valleys have been formed, or greatly enlarged, by the action of streams and rivers; but these cannot be considered as the usual agents, for valleys abound where there are no streams which could have hollowed them out. In many cases, slow running rivers have rather a tendency to fill up valleys, by accumulating sand and soil from the surface of the countries through which they flow.

Earthquakes are frequently the cause of fissures and depressions of the earth's surface. Several hollows of this nature are to be found in volcanic countries.

The immense hollow valley in central Asia, near the Caspian Sea, has been already alluded to; and Humboldt conjectures that this depression of three hundred feet below the ocean level may have taken place when the neighbouring ranges of mountains were thrust up from below, forming the highest ground on the surface of the globe.

SECTION XIV.

THE OCEAN.

129. The ocean consists of one vast volume of water, which may be said completely to surround the globe. All the great divisions of it join each other; and, with few exceptions, the smaller seas are but arms or portions of the wide mass.

This expanse of waters, covering fully more than two-thirds of the earth's surface, has been divided into five oceans,—the Atlantic, the Indian, the Pacific, the Arctic, and Antarctic.

The inland seas are the Mediterranean, the Baltic, the Black Sea, and the Caspian.

From the known properties of all fluids to preserve a uniform level, it might in theory be supposed that this ocean surrounding the globe would be found of a uniform level throughout. Experience, however, seems to indicate the reverse. From some levels which have been taken, it has been ascertained, that the mean height of the Pacific above the Atlantic is about three feet and a half.

These inequalities of level may be owing to tides and currents, by which the ocean is continually agitated, thus hemming in its waters at particular places; these causes acting with greater power in inland seas communicating with the ocean by narrow channels.

130. The water of the ocean derives its peculiar taste from certain salts dissolved in it. These consist of muriate of soda, or common salt, muriate of magnesia, and muriate of lime.

According to the analysis of the late Dr Murray, ten thousand parts of water from the Firth of Forth contained

Muriate of soda, ...	220.01 parts.
Sulphate of soda, ...	33.16
Muriate of magnesia, . . .	42.08
Muriate of lime, . . .	7.84

According to Dr Marcet's analysis, ten thousand parts of sea water contained

Muriate of soda, ...	266 parts.
Sulphate of soda, . . .	47
Muriate of magnesia, . . .	52
Muriate of lime, . . .	12

The proportion of saline matter is nearly the same in every region of the globe. At the equator it is said the saltness increases in a slight degree, which may be accounted for from the increased evaporation constantly taking place there.

The depth of the ocean varies much at different places, the same irregularity of its bottom existing as that which occurs on the surface of the dry land. The medium depth has been calculated at from two to three miles. Its extreme depth probably equals that of the extreme height of our mountains, and may be from five to six miles.

The vast expanse of the ocean, its incessant motion, and its animals and plants, all differing from those of land, render it an object of peculiar interest.

131. Although water less powerfully absorbs the sun's heat, yet as it cools more slowly than the earth, and as its tides and currents are continually mingling the equatorial and polar portions of it together, we have thus an agent for the diffusion of heat to every quarter of the globe. Thus islands surrounded by the ocean have a more equable temperature, or milder winters, and less scorching summers, than large ranges of continent.

Besides the regular rising and falling of the tides, which is caused by the attractions of the sun and moon, the ocean is also influenced by the unequal tropical and polar temperatures, these causing currents somewhat similar to the trade currents of the atmosphere. There are two great currents of this nature which are continually prevailing,—a current flowing from the tropics westward, and another from the poles towards the equator. The current flowing from east to west extends between 30° south and 30° north latitude, and moves with a velocity of ninety-nine or one hundred miles a-day. In the Atlantic it separates into two branches, one of which forms the gulf stream. This branch flows northward through the middle of the Atlantic, till it reaches the Cape de Verd Islands. It there turns west—passes the Caribbean Sea, and the strait between Cuba and Yucatan—winds round the Mexican Gulf, and rushes out by the Bahama Channel—then, spreading out to a greater breadth, it sweeps along the shores of the United States to Newfoundland. At this point it is bent south-eastward by a southerly current from Baffin's Bay, and, passing the Azores and Canary Islands, returns in a great measure into itself, and repeats its round. The waters of the North Atlantic, between the latitudes of 11° and 43° thus form a continued whirlpool, completing a circuit of three thousand eight hundred leagues in about

thirty-four months. Its velocity is greater as the depth and breadth are less. Its breadth is fifty-one leagues in the Bahama Channel, and velocity from three to five miles an hour In its retrograde course from longitude 50° to the Azores, the breadth is one hundred and sixty leagues, and velocity from seven to eight miles a-day. An insulated expanse of almost motionless water, one hundred and forty leagues in breadth, occupies the interior of the circuit. This grand current sends off one branch near Newfoundland, which proceeds north-eastward, and sometimes deposits tropical fruits on the shores of the British Isles and Norway. A second branch, escaping at the Azores, enters the Straits of Gibraltar, and forms the upper and middle currents which prevail in that strait. Another branch of the great tropical current sets along the coast of Brazil, and at length passes through the Straits of Magellan. In the Pacific, the waters have a general westward motion from the coast of Peru, which must be partly supplied by the last mentioned current after doubling Cape Horn. The current from the coast of Peru is less perceptible, till it enters the Indian Ocean, when, strengthened by the westerly currents there, it flows along the eastern coast of Africa, and doubles the Cape of Good Hope in a rapid stream, one hundred and thirty miles broad, and seven to eight degrees warmer than the surrounding sea. A current from the South Pole sets along the west side of New Holland into the Bay of Bengal. It is supposed that other portions of the general polar current deflect the great westerly current northward after it has passed the southern promontories of Africa and America. In the Northern Ocean, in the space comprised between Greenland and the coasts of Britain and Norway, and between Labrador and Spitsbergen, a great body of waters, acted on by three or four lateral currents, is supposed to perform a perpetual circuit. These waters receive their impulse eastward from a branch of the Gulf stream, which passes from Newfoundland along the north-west coasts of Scotland and Norway. At the North Cape, in Lapland, a great westerly current from Nova Zembla turns the waters north-westward along both sides of Spitsbergen. Beyond this island, being met by a current from the pole, they turn south-westward, and pass along the coast of Greenland to Davis' Straits, where they are deflected southward by a fourth current from Baffin's Bay, and, having returned to Newfoundland, recommence their revolution.

Thus, two great whirlpools, connected with one another, touch at the bank of Newfoundland, which seems to be a bar cast up by their conflicting waters, and, revolving in opposite directions, occupy four-fifths of the North Atlantic. The small current which sets from the Bay of Biscay across the mouth of the English Channel, and through St George's Channel, is most probably a branch of the Gulf stream, which had come off at the Azores.

SECTION XV.

RIVERS, LAKES.

132. From the surface of the sea, there is continually ascending a portion of its water in the form of vapour, which mingles with the air, and which, mounting to the higher parts of the atmosphere, forms clouds.

This evaporation is greatest at those places where the sun's

rays produce the greatest heat, and is also influenced by currents of wind, electricity, and other causes.

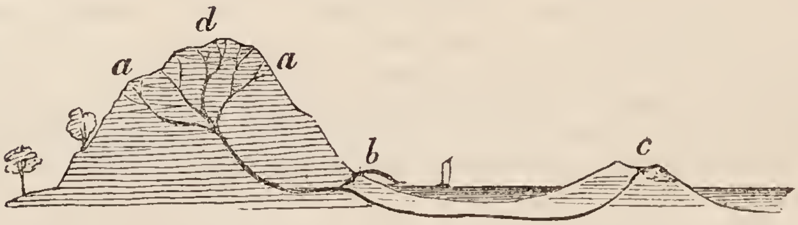
Pure water only thus evaporates, the saline particles remaining behind. This vapour, collecting into clouds, is borne along in the atmosphere, and at last descends in rain upon the earth.

133. The forms and densities of these clouds vary according to the quantity of moisture in the air, and the various elevations to which they ascend. The lightest vapours mounting highest, are called *cirri*, the middle clouds *cumuli*, and the lower *stratus* or mists, and *nimbi*, or rain clouds.

Part of this rain water goes to the support of animal and vegetable life ; part flows along the moist surface of the earth ; while the remainder sinks into the cracks and porosities of the strata ; and after filtering through many deep winding channels, at last emerges to the surface, forming springs and fountains. These uniting together, compose large streams ; which, again accumulating, join into one great river, that winds its course through valley and meadow, till it reaches the ocean, the original source from whence it came.

Thus, we have an unceasing operation taking place on a most magnificent scale, by which the otherwise dry and barren earth is moistened by the purest portions of the ocean, and rendered fit for the nourishment of plants and animals ; and so essential is this beautiful provision of nature, that were the process interrupted for even a very short period, the world would be turned into an arid waste.

No. 35.



134. An illustration of the manner in which springs and rivers are formed is given in the above diagram. *d* represents an elevated mountain, with numerous fissures, *a*, *d*, *a*, in the strata, through which the rain water sinks downwards.

As it is a property of all fluids to descend until they attain the lowest levels, the water flows through the fissures till it attains the opening at the base of the mountain *b*, where it issues in the form of a spring, or a river discharging itself into the sea. Or the fissures in the strata may extend in a winding course below the sea level, till they reach an island as at *c*, and

this point being still below the original level *d*, the water will here also flow out freely.

In this way, may be explained the manner in which islands are supplied with water from springs, independent of the rain which falls on their surface.

Artesian springs, so called because they are of frequent occurrence in Artois, a province of France, are caused in the same manner by streams of water flowing from a higher level through fissures in the earth's strata. When the upper portion of the strata is bored through, till the water is reached, it flows upwards with considerable force to the surface. In many other countries, by piercing the upper surface, we come to springs thus running through the subordinate strata. This is especially the case where sandstone or limestone is intersected by trap dykes.

135. *Thermal springs* are those which flow out of the earth with an elevated temperature, approaching sometimes to that of boiling water. They are found in various parts of the world; and must, in many instances, come from a great depth, and are supposed to derive their heat from deep volcanic fire. The water of springs is also frequently impregnated with various salts and metals; hence, these are called *mineral springs*.

Mineral waters are distinguished into,

Acidulous, containing the carbonic, muriatic, or sulphuric acids, combined with soda, magnesia, and lime, as those of Seltzer, Pyrmont, and Spa.

Sulphurous, containing sulphuretted hydrogen, and small portions of the above salts, as those of Harrogate, Moffat, Aix-la-Chapelle.

Saline, containing a considerable portion of carbonate, muriate, or sulphate of soda and magnesia, as Seidlitz, Cheltnam, Dunblane, Pitkeathly.

Chalybeate, containing carbonates of iron, with portions of other salts, as Tunbridge, Toplitz.

Calcareous hot baths, containing carbonate of lime, as Bath, Buxton, Matlock, Malvern.

136. *Lakes* are found in the hollow basins of mountains or valleys, which, being shut up, allow the waters of springs to accumulate. The excess of water frequently flows out of these lakes in the form of a river, or it is carried off by evaporation.

Inland lakes not unfrequently wear down their barriers, and thus a natural process of draining takes place. A slow operation of this description seems to be going on at the celebrated falls of Niagara in North America.

Lakes and rivers form magnificent objects in the scenery of nature. They are found of greater or less magnitude in every country where there is an inequality of the surface.

America possesses the most magnificent fresh water lakes. Lake Ontario, Lake Erie, Lake Huron, and Lake Superior, are of such extent as rather to be styled inland seas than lakes, although they are of fresh water. Lake Ontario exceeds three hundred fathoms in depth. They are all navigable for ships of the largest size. For picturesque beauty, the Lake of Geneva and Lucerne, in Switzerland, Como in Italy, Loch Lomond in Scotland, and Windermere and Grassmere in Cumberland, are pre-eminent.

137. The largest rivers in the world are the Amazons and La Plata in South America ; the Mississippi in North America ; the Ganges in India ; the Hoanho and Obe in China and Tartary ; the Danube, the Don, and the Rhine, in Europe.

The river Amazon, in South America, takes its rise in the Andes ; and after a long sweep of a thousand miles' distance along the foot of those lofty mountains, and collecting the accumulated streams which flow from these, it rolls westward across the great plain. It again receives large tributaries from the eastern ranges of Peru on one side, and Brazil on the other; and before reaching the Atlantic, is swelled into the width of an inland sea.

The several streams which join to form the huge Mississippi, take their rise in the great range of the rocky mountains in North America, and flowing southward over a tract of continent of from two to three thousand miles, discharge their accumulated waters into the gulf of Mexico. The chief streams which join to form this immense accumulation of water, are the Missouri, the Arkangas, and Red River, on the west ; and the Illinois, the Ohio, the Wabash, the Shawannie, the Kentucky, and Tenessee, on the east. The great valley intersected by these streams, is the largest and most fertile in the world. The Mississippi is navigable to the falls of St Anthony, upwards of fifteen hundred miles from its mouth, and the tributaries are almost all navigable nearly to their sources ; thus affording the utmost facilities of communication through this valuable tract of territory.

138. The falls of Niagara are the most extensive and magnificent in the world. The Niagara flows out of lake Erie, and joins lake Ontario, at the distance of thirty-five miles. The falls are twenty-one miles from lake Erie. A small island divides the current into two cataracts, one of which is six hundred yards wide, the other three hundred and fifty. The height from whence this immense torrent of water is precipitated, is from one hundred and forty to one hundred and sixty feet.

It is estimated that six hundred and seventy thousand tons of water are dashed every minute with inconceivable force against the bottom. The rock over which the cataract flows is limestone ; it is continually crumbling down by the incessant action of the water ; and as a hollow channel nearly a mile wide, with precipitous sides, exists for seven miles below the falls, it has been conjectured, that originally the cataract has been at Lewestown, seven miles nearer lake Ontario, than the present position ; and that, consequently, the falls are slowly, but perceptibly, wearing upwards.

The great falls of the Missouri are three hundred yards wide. The river dashes in an undivided sheet, at least eighty feet perpendicular. Then follows a succession of falls and rapids. Above the great fall, there is another thus described by Captain Lewis. " The whole Missouri is suddenly stopped by one shelving rock, which, without a single niche, and with an edge as straight and regular as if formed by art, stretches itself from one side of the river to the other, for at least a quarter of a mile. Over this, it precipitates itself in an even uninterrupted sheet, to the perpendicular depth of fifty feet, whence dashing against the rocky bottom, it rushes rapidly down, leaving behind it a spray of the purest foam across the river. The scene which it presented was, indeed, singularly beautiful, since, without any of the wild irregular sublimity of the lower falls, it combined all the elegancies which the fancy of a painter would select to form a beautiful waterfall."

The height of the great cataract of the Rio de Bogoto, in South America, is about eight hundred feet. The small river Ache, in Bavaria, has, however, the extraordinary fall of two thousand feet. It has five great falls ; the last of which forms a most magnificent arch of waters, which is entirely converted into spray before it reaches the ground. The roar of this cataract is heard at the distance of a league.

The fall of Garispa, in India, is one thousand feet. In Scotland, the falls of the Clyde, near Lanark, are the most considerable for the mass of water discharged. The celebrated fall of Foyers, in Inverness-shire, has two falls of forty and ninety feet.

In many of these cataracts, the abrasion of the rocks over which they flow, indicates the gradual effects of the force of running water ; and as the falls have evidently sunk from their original levels, such appearances have been deemed to afford some data for calculating the period when the surface of the country assumed its present appearance.

SECTION XVI.

METALLIC VEINS AND ORES.

139. The various metals are found disseminated through the earth's strata, either in beds or masses; in minute particles among the debris of rocks; or in veins which run through various rocks and strata.

With the exception of gold and platina, metals are rarely found in a pure state, but are generally combined with other substances. Sulphur is the most common ingredient of metallic ores, and when metals are combined with this substance, they are called *sulphurets.* Oxygen and the acids also enter into combination with the metals, converting them into earthy looking substances, and destroying all their usual metallic aspect and character. Hence, metallic ores, when dug out of the earth, have to undergo first the process of roasting, or subjection to a considerable heat, to free them from sulphur; and afterwards, smelting, or the application of a greater heat, combined with various fluxes, to reduce them to their true metallic character.

Metallic ores occupy cracks or fissures in rocks; and are supposed to have been injected in a fused state into such fissures during the various convulsions which have occurred in the earth's strata. Certain earthy substances accompany the metallic ores, and serve to fill up the remaining space of the fissures. These substances are called the matrix, and consist generally of quartz, of carbonate or sulphate of barytes, of fluor spar, or sometimes of soft clayey materials.

These metallic veins are represented shooting from below upwards, through the strata, figure 2 v. v. They are common in all the rocks of the primary and secondary series, onwards to the new red sandstone; beyond which, no metals occur in any of the members of the sedimentary strata, with the exception of iron, which metal is universally diffused, and in the state of oxid, or other combinations, imparts the red or brownish tinge to the various earths. An idea of a metallic vein may be formed, by supposing a crack to take place in the soil, forming a narrow fissure, extending for several yards east and west on the surface, and descending in a more or less inclined direction towards the earth's centre. This fissure is then supposed to be filled partially with the earthy matrix, or mould; and afterwards, the fused metallic substance, insinuating itself throughout the vacant space, fills up the whole.

The general direction of metallic veins is from east to west; these veins are called *lodes*, or right running. Occasionally, however, other veins, from north to south, cross these, and either join with or dislocate and interrupt them ; such are called *cross courses*.

The same metallic vein at different depths frequently changes its character. Thus, in some of the mines of Saxony, iron, copper, and cobalt ores succeed each other in one continuous vein. In France, some mines at the top contain iron ; this is succeeded by silver, and copper ore is found below.

In Cornwall, tin and copper, and zinc and copper, are frequently found succeeding each other. Metallic veins vary in shape and thickness ; they are either flat and compressed, or rounded, or angular. They sometimes swell out into considerable width, and then contract into a narrow space. Branches of veins often divide and unite again, and occasionally they separate into very minute ramifications, called *strings*. The thickness of metallic veins varies from a few inches to several feet or yards. Even the same vein varies sometimes from six inches to forty feet in width. Molina mentions a vein of silver at Upsalata, in the Andes, which is nine feet in thickness throughout an extent of ninety miles. Smaller veins branch out from this larger one, and penetrate the neighbouring mountains to the distance of thirty miles.

In Cornwall, the common width of veins is from one to two feet, although occasionally they are found thirty feet. The greatest length is two miles. The depth to which metallic veins extend is unknown, as there is no instance of a vein having been wrought to a termination. They are usually abandoned, either from the depth becoming too great, or from the vein falling off in richness, so as not to repay the expense of labour. Veins are not so rich in metals either near the surface, or at an extreme depth, the middle portion proving the most profitable. The deepest mine in England is the Eaton copper mine, Staffordshire, which is four hundred and seventy-two yards; and the extreme depth to which mining operations have been carried is in Fruttenbergh, in Bohemia, which is nearly three thousand feet below the earth's surface.

Metals are sometimes found in beds interposed between layers of rock. This is the case with iron and copper, but rarely with the other metals. Iron also is found in nodules, or round balls, which are regularly strewed among strata of shale and ironstone. There are masses of iron ore of such magnitude as to form mountains in Sweden and Norway.

140. Metallic veins are wrought by digging a shaft down to the vein, by which the workmen descend and quarry it out. As frequent springs of water are met with, it is necessary to open up other horizontal tunnels, proceeding from this perpendicular shaft, by which the water may be drained off.

The metals are the heaviest bodies in nature, and the most compact and opaque of minerals. They have all more or less of that peculiar lustre known under the name of metallic. They are in various degrees malleable, or can be beat into plates; ductile, or capable of being drawn into wires; and flexible, or easily bent. A few possess these qualities in an eminent degree, and have hence been called perfect metals—as

Gold	Copper
Platina	Iron
Silver	Lead
Quicksilver	Tin

The others possess these properties in a less degree, as

Zinc	Titanium
Bismuth	Tellurium
Antimony	Chromium
Cobalt	Tantalum
Nickel	Cerium
Manganese	Iridium
Arsenic	Palladium
Molybdenum	Cadmium
Tungsten	Osmium
Uranium	Rhodium

Platina, palladium, rhodium, osmium, and iridium, have only been found in the sands of rivers. Gold and silver are found in granite, gneiss, syenite, porphyry, greywacke, and the oldest sandstones. Gold has been sometimes found in coal, and volcanic rocks, and is disseminated extensively, in minute particles, in the sands of some rivers. In many of the rivers of Africa and South America, gold dust is obtained in considerable quantities. The sand containing this dust is collected and washed in hollow troughs. The sediment first deposited in these troughs contains the particles of gold, which, being heavy, settle immediately at the bottom, while the sandy particles are poured off. This operation is repeated again and again, till at last the gold dust is procured in considerable quantity. It is then mixed with quicksilver, which has the property of amalgamating with, or dissolving all the gold, and leaving undissolved the remaining sandy particles. The mixture of gold and quicksilver is then taken and subjected to heat-

in iron retorts, by which the mercury is evaporated, and the solid gold remains at the bottom.

Silver is sometimes found native or pure, but more commonly combined with other matter, forming sulphurets, arseniates, &c. Silver is found in small quantities in the mountain limestone of England and Scotland, and various parts of the Continent. But the mines of New Spain are the richest in the world. Upwards of one million and a half troy pounds of this metal are annually produced from these mines, being one-third of the whole annual produce of the globe.

Quicksilver is found in slate, limestone, and coal strata, occasionally native, but more generally as a red sulphuret or cinnabar. It has the peculiar property of remaining in a fluid state at ordinary temperatures. The mines of Peru furnish this metal in great quantities.

Copper ores are found as sulphurets, as copper pyrites; or carbonates, assuming a beautiful blue colour, as malachite, or green copper ore; and phosphates and arseniates of copper. Ores of copper are found in porphyry, syenite, greywacke, and red sandstone. Masses of native copper, of many thousand pounds weight, are said to exist in the superficial strata in the interior of North America.

Iron is the most abundant of all the metals, being found in every kind of rock, in sand, and alluvial soils. In small portions it has been found native, and possessed of magnetic properties. Iron pyrites, or sulphuret of iron, is a very common cubical crystal, found in slates and shales. Hematite, or brown iron ore, is also very common, and clay iron ore, and brown compact ore, are the kinds most usually employed for smelting.

Tin ore exists as an oxyd and crystallized in granite, gneiss, mica slate, and clay slate, but not in limestone. It is most abundant in Cornwall.

Galena, or sulphuret of lead, is the most usual form of this metal. It also exists as a carbonate and phosphate, and, along with zinc, is found in primary rocks, in greywacke, and most abundantly in mountain limestone.

Small crystals of galena are also found in the trap rocks in the neighbourhood of Edinburgh.

Antimony, nickel, bismuth, and manganese, in the form of oxydes and sulphurets, are found in the primary rocks.

SECTION XVII.

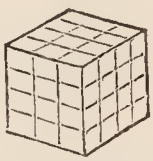
MINERALOGY.

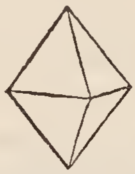
Mineralogy comprehends a description of the forms, combinations, and properties of earths, metals, salts, and other inorganic substances. The geological rocks already described exist in large masses, — minerals are found in comparatively small quantities, in veins and beds, in the fissures and cavities of the different rocks. Mineral substances exist in a massive shapeless form, or they are crystallized. Almost all inorganic bodies, in passing from the fluid to the solid state, under favourable circumstances, assume a crystalline form. When this form exists, then, it presupposes a previous state of fluidity, either by aqueous solution, or igneous fusion.

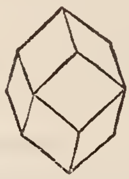
The first crystals observed by the ancients, were those of transparent quartz, and were fancied to be congealed water or ice ; hence the Greek name *κρυϛαλλος, ice,* and the term crystallization.

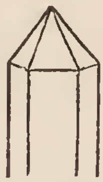
Different bodies assume various shapes of crystallization, which have been all resolved into the following primary forms.

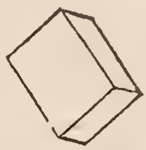

Tetrahedron.


Cube.


Octohedron.


Dodecahedron.


Prism.


Parallelopiped.

By modifications and combinations of the above primary crystals, all the varieties in nature are produced, and every large crystal is composed of numerous minute ones of some of the primary forms, built up upon each other. Thus the cube may be separated into innumerable smaller cubes ; an arrangement of these simple cubes may form the prism ; or the octohedron may, by the addition of smaller cubes to its angles, be converted into a larger cube. A crystal, then, though composed of numerous primary crystals, is not necessarily of the same form as these. The primary crystal of carbonate of lime, is an obtuse rhomboid, and yet there are no less than five hundred forms of crystals of the same mineral.

Some minerals, on the other hand, are characterized by one invariable form of crystallization.

The distinctive characters of minerals are, hardness, fracture, transparency, lustre, colour, flexibility, refraction, touch, taste, odour, streak, and magnetic and electric properties.

The most philosophical arrangement of minerals, is according to their chemical composition, classifying them under the heads of those simple substances, which are found in greatest proportion in each. Thus, when silex predominates, the minerals are arranged under the head of silicious: when alumina, aluminous, &c.

Minerals are divided into I. Earthy; II. Alkaline; III. Metallic; and IV. Inflammable.

EARTHY MINERALS.

Silex, Water.

Quartz (*Rock crystal, flint*) — Hard, inodorous; insoluble in water, and all the acids except the fluoric; phosphorescent when rubbed in the dark; variously coloured, transparent, milk white, rose, violet, yellow, brown; common form of crystal, six sided prism terminated by a six sided pyramid; primary form, rhomboid.

Avanturine — Base of a reddish brown quartz, with golden scales of mica disseminated.

Prase—Dark green quartz enclosing actynolite.

Rose quartz—Of a ruby colour, from admixture of manganese.

Amethyst—Violet colour; from iron and manganese.

Yellow quartz — (*Cairngorm.*) Of various shades of yellow, brown.

Hyalite—In yellow masses like gum-arabic; found lining the cavities in trap rocks.

Cat's eye—Various shades of green, grey, brown, or red; changing these colours like the eye of the cat.

Opal—Colour, white, blue, yellowish white, changing to green, blue, yellow, red; varieties—precious opal; fine opal; common; semi-opal; hydrophane, which becomes transparent in water; menelite, smoke brown pitchy.

Flint—Colour, grey, yellow, black; found in nodules in chalk.

Calcedony—(*So called from Calcedon, Upper Asia.*) Semi-transparent, uncrystallized, bluish white, a deposition of silex from an aqueous solution; found in veins, nodules, clusters, and lining cavities with central crystals of quartz.

Onyx—Consisting of alternate layers of brown and white calcedony, which may be polished, so as to form a resemblance to the eye of the Lynx or Onyx. Sardonyx, a variety from Sardinia.

Heliotrope — (*Blood stone.*) Deep green, with blood red spots interspersed; calcedony, coloured with chlorite or green earth.

Chrysophrase—Colour, apple green; translucent; softer than calcedony; containing oxyd of nickel.

Carnelian — (*Flesh-like.*) Colour, white, yellow, brown red; found in form of grey nodules, which are exposed to heat in order to bring out the colour.

Silex, Alumina, &c.

Agate — (*Perhaps so called from the river Achate; Scotch pebble;*) chiefly composed of a base of calcedony, with intermixture of alumina and other earths, and oxides variously coloured; varieties — ribbon agate, striped with jasper, amethyst, &c. fortifica-

tion agate, resembling, when polished, the lines of a fortification:

Mocha stone — With appearances of vegetable fibres; sometimes real petrified mosses and plants, at other times, arborescent crystals of manganese, &c.

Jasper — Opaque, uncrystallized, hard; varied mixtures of colour, yellow, brown, red, green, being most prevalent; varieties—striped or ribbon jasper; Egyptian, light cream colour, white, brown, and black shades; porcelain, bluish grey, red; agate jasper, forming nodules in trap rocks.

Hornstone — Rather softer than quartz; colour, grey, with tinge of green, blue, brown; occurs in round masses in limestone.

Chert — Massive, waxy, lustre; colour, various; embedded in mountain limestone.

Silicious sinter—A deposit of silex from hot springs; colour, white, grey; variety—pearl sinter.

Garnet—(From grenat, pomegranate seed.) Form of crystal, rhombic dodecahedron; colour, red, yellowish brown; found chiefly in mica slates; varieties—precious garnet, common garnet, pyrenite; colour, black; aplome, deep brown; magnesian garnet, hyacinth, red; melanite, black, found in volcanic rocks. Pyrope, occurs in angular grains, red, transparent. Topazolite, topaz yellow, and olive green.

Silex, Alumina, Lime.

Cinnamon stone—In masses of small adhering grains, interspersed with crystals; translucent; lustre vitrio-resinous; colour, brown, orange yellow.

Idocrase—Massive; oftener crystallized into quadrangular prisms; colour, brown, yellow, orange; found in lava, serpentine, &c. Egeran is a variety, found in Eger, in Bohemia.

Gehlenite — Rectangular crystals, approaching the cube; colour, grey, greenish; found accompanying calcareous spar.

Prehnite (after Colonel Prehn)—Fibrous, massive; colour, light green, yellowish pearly lustre; scarcely harder than glass; found in trap rocks.

Stilbite—Of a glistening pearly lustre; colour, white, grey, brown; translucent; crystals, slender prisms; yields to the knife.

Heulandite—Crystallized, an oblique angled prism; massive, in a globular form; colour, white, yellow, and deep red; found in trap rocks.

Thomsonite—In masses of a radiated structure, and crystals of right prisms, with square basis; colourless, with pearly lustre; translucent.

Epidote—Granular massive; in prismatic crystals; colour, green, yellowish, or bluish; scratches glass; found in veins and fissures of primary rocks; variety—magnesian, granular.

Lapis lazuli — Massive; colour, beautiful azure blue; scratches glass; nearly opaque; in powder forms the paint called ultramarine.

Flint slate—Laminar, quartzose; colour, grey, blue, and edges translucent.

Lydian stone—Hard massive; colour, black, or greenish black; opaque; found along with flinty slate, quartz, &c.

Lithomarge—Massive, soft, friable, adheres to the tongue; colour, reddish, white, grey.

Tripoli—Massive; earthy fracture; colour, grey, yellowish.

Silex, Alumina, Lime, Magnesia.

Augite (pyroxene)—Small crystals; oblique rhombic prism; colour, green, brown, black; opaque; found in basalt and volcanic rocks; varieties — diopside, pyrgomine, sahlite.

Hornblende — Prismatic crystals; confusedly aggregated; colour, dark bottle green, brown, black.

Tremolite — Masses of delicate fibrous crystals, and four sided prisms; colour, white, yellowish, reddish; varieties—granular, fibrous, asbestiform.

Actynolite—Crystallized hexahedral prisms; colour, pale green; asbestiform in capillary crystals; radiated, green, greenish grey; glassy, with vitreous pearly lustre.

Hypersthene — Massive, hard; colour, dark green or black.

Schiller spar — Massive, opaque; olive or bottle green; found in serpentine.

Asbestus—fibrous; soft silky feel; green; variety — amianthus, mountain leather, mountain wood. Amianthus is flexible, minutely fibrous, and may be wove into cloth, and made into paper, both of which resist fire.

Alumina Water.

Sapphire (corundum) — In crystals of six sided prisms; rolled masses; in hardness, inferior only to the diamond; colour, blue, yellow, greenish; transparent; composed of almost pure alumina; varieties, from colour — oriental sapphire, amethyst, topaz, emerald, girasol, &c.

Oriental ruby—Blood red, rose red, violet tinge.

Common corundum—Grey, greenish, nearly colourless; translucent.

Emery — Massive, hard; colour, bluish grey; reduced to powder is used in polishing stones, &c.

Calaite (oriental turquoise) — In masses the size of a nut or egg; colour, greenish blue, of various shades, from sky blue to apple green.

Alumina, Silex, &c.

Topaz—In round masses, and crystallized; prismatic; colour, transparent, yellow, green, blue, lilac, red; found in primary rocks, accompanying tin veins; variety — pyro-physalite.

Chrysoberyl—Massive, crystallized; rectangular prism; semi-transparent; colour, green.

Spinelle ruby—Found in grains, or octohedral crystals; colour, red, violet, yellow; scratches quartz; variety—pleonaste.

Iolite—Massive, or crystallized in six or twelve sided prisms; colour, purple.

Magnesia, Silex, &c.

Hydrate of magnesia—In laminar plates, and hexahedral prisms; colour, white, greenish.

Chrysolite — Angular and rounded crystalline masses, or in prismatic crystals; colour, yellow, greenish.

Olivine—Massive, and crystallized, semi-transparent; colour, olive green; occurs in basalt and meteoric stones.

Condrodite — In small grains, and occasionally rhombic crystals; colour, wine yellow.

Serpentine — Massive; colour, various shades of green, yellowish green; soft, fracture splintery; resinous lustre; found in beds in primary rocks; varieties—noble; common, with various shades of green, brown, red.

Zircon, Silex, &c.

Hyacinth — Lamellar octohedral crystals, translucent; colour, various shades of red, orange.

Jargoon — Small transparent crystals, prismatic; colour, grey, yellow, brown; found in the sands of Ceylon.

Zirconite—Prismatic crystals, opaque; colour, reddish brown.

Glucine, Silex, &c.

Euclase — Prismatic crystals; colourless, or light green.

Beryl, (aquamarine) — Hexahedral prism; colour, various shades of yellow, green, blue; harder than emerald; found in granite.

Emerald—A six sided prism; colour, a beautiful green.

Gadolinite—Massive and crystallized; colour, greenish, or brownish black; opaque.

Silex, Alumina, Potash.

Mica — Massive laminar, and in six sided crystals, and rhombic prisms; colour, white, brown; shining, silvery; found in granite.

Leucite — In rounded crystalline masses; colour, grey, white.

Andalusite—Massive, and in rhombic prisms; lamellar, jointed; colour, reddish; scratches glass.

Apophyllite—In square prisms; lamelar; colour, white, grey.

Pearl stone—In large round angular concretions; lamellated; lustre pearly; colour, grey, whitish.

Silex, Alumina, Magnesia, Potash.

Felspar—Massive, crystallized; lamellar; scratches glass; varieties—adularia, (moonstone,) semi-transparent, iridescent; colour, milk white, grey. Glassy felspar, crystallized, vitreous lustre; colour, greyish, yellowish. Labrador felspar, beautifully iridescent; colour, grey, green, blue. Blue felspar; colour, pale sky blue, lamellar. Crimson felspar, opaque vitreous lustre; colour, white, yellow, red.

Talc — Massive, and in hexagonal tabular crystals, laminar; colour, white, yellowish, green; flexible, but inelastic; unctuous, soft; massive talc is less flexible, with radiated structure; colour, apple green.

Soapstone — Massive, soft, soapy feel; colour, grey, yellow.

Steatite — Colour, grey, yellow, green; found in serpentine.

Chlorite — Compact; slaty; crystallized; earthy; colour, dark green, yellowish green; lustre shining, opaque; soft unctuous feel.

Schorl—Massive, crystallized, a longitudinally striated prism, minute, brittle; colour, black, brown; first found at Schorlam, Saxony; common in primary rocks.

Killinite—Massive; prismatic crystals; colour, light green.

Silex, Alumina, Lime, Soda.

Mesotype (*zeolite*)—Fibrous rhombic prisms, radiated; colour, grey, white; earthy variety, found in traprocks. Mesolite also a variety.

Natrolite—In round masses, internally fibrous; colour, white; pearly lustre.

Clinkstone—Massive, edges translucent, hard; colour, brown, greenish.

Pitchstone — Massive, prismatic; colour, dark green, brown, black,

Lava—Massive, compact or porous; colour varies from grey to black.

Basalt — Columnar, amygdaloid, opaque; colour, black.

Silex, Alumina, Lime, Potash, Soda.

Jade—(Nephrite) massive, hard; colour, leek green; variety—axe stone, colour, light green.

Obsidian—In large masses, and in grains, shining vitreous lustre; colour, dark green, black; found in volcanoes.

Chabasie — Obtuse rhomboid crystals; colour, white, pale red.

Tourmaline — Prismatic crystals; colour, green, blue, black; softer than quartz; becomes electric by heat.

Spodumene—Massive laminar; lustre shining; colour, grey.

Wavelite—Rhombic prismatic crystals, translucent; colour, yellowish white; a phosphate of alumina, with fluoric acid.

Lime, Carbonic Acid.

Calcareous spar — Crystallized in five hundred varieties of form; primary crystal, an obtuse rhomboid; sometimes transparent; colour, white, and other hues; easily scratched with a knife; effervesces with acids; exhibits double refraction.

Schieffer spar — Massive, in thin tabular plates, slatey; colour, white, green, reddish; pearly lustre.

Satin spar—In fine parallel fibres; colour, white; silky lustre; harder than calcareous spar.

Agaric mineral—Light, soft, powdery; colour, white, grey.

Stalactites — Long, tangle shaped, masses; colour, white, grey; formed of carbonate of lime deposited from water, dropping from the roofs of caverns. The cave of Castleton, in Derbyshire, and the spar cave in Skye, are the

most remarkable in Britain. Oriental alabaster is procured from stalactites of lime.

Stalagmites—The flat masses formed by the deposition of lime water on the floors of caverns.

Peasolite (*peastone*)—Opaque, soft, with round bodies like peas imbedded in a base of limestone.

Madreporite—Prismatic diverging concretions, imbedded in a mass; petrified coral.

Tufa (*kalk tuff*)—Cellular, light, brittle; often invests vegetable and animal remains.

Arragonite—Massive, fibrous; lustre silky; branches of fibrous crystals diverging from a centre.

Pearl spar—Massive, and in obtuse rhomboid crystals; lustre, pearly.

Dolomite—Crystalline fibres, radiating from a centre; colour, yellowish; in magnesian limestone.

Apatite—Massive, and in six sided prismatic crystals, translucent; yellowish white; a phosphate of lime.

Lime, Fluoric Acid.

Fluor spar (*fluate of lime*)—Primary crystal, the octohedron forming the cubic dodecahedron, rhomboid, &c. colour, white, transparent, purple, green, yellow, red, blue; gives out phosphoric light when heated; varieties—nodular, compact, earthy.

Lime, Sulphuric Acid.

Gypsum—Crystallized, granular, fibrous.

Selenite—In flat crystals, oblique parallelopipeds; shining pearly lustre, translucent, white, soft.

Compact gypsum or *alabaster* is formed into ornaments, vases, &c.

Magnesia, Carbonic Acid, Barytes, Strontites.

Carbonate of magnesia—Compact opaque, dull, soft; colour, yellowish.

Carbonate of barytes—(*witherite*, from Dr Withering,) Massive, crystallized into prisms; heavy; colour, white, grey.

Sulphate of barytes, (*heavy spar*)—Massive, lamellar; in right rhombic prismatic crystals, transparent or opaque; colour, white, yellowish, red; very heavy; several varieties.

Strontian, (from village in Scotland)—Massive, fibrous, stellated, and in hexahedral prisms; colour, grey, green.

Celestine, (*sulphate of strontian*)—Massive, fibrous; colour, white, red, blue; shining lustre.

ALKALINE MINERALS.

Nitrate of potassa, (*nitre*)—In capillary crystals; colour, white; brittle, saline taste, deflagrating on hot charcoal; found in plains, old walls, chalk, &c.

Natron, (*carbonate of soda*)—Massive, and in fibrous radiated crystals; colour, grey; taste, saline, easily soluble in water; found in the water of springs and lakes.

Sulphate of soda—In springs, and sea water.

Borate of soda, (*borax*)—In prismatic crystals, and rhombic prisms; colour, grey; used as a flux for metals, and found in water of lakes, in Thibet, &c.

Muriate of soda, (*common salt*)—In beds and masses; crystallized; in salt springs, and sea water; colour, brown, from oxide of iron.

Sulphate of ammonia—In stalactites; colour, grey; taste, bitter; found in fissures of the earth, near lakes in Tuscany.

Muriate of ammonia—Massive, fibrous texture; pungent taste; found in volcanoes.

Sulphate of alumina, (*alum*)—In the form of efflorescence on slates; also crystallized; taste, sweetish styptic.

METALLIC MINERALS.

Gold, (*native*)—In cubical, and octohedral crystals; colour, bright yellow; in alloys of copper, silver, iron; found in quartz, veins in primary rocks, and in the sand of rivers and alluvial deposits; variety, argentiferous, (electrum,) combined with silver.

Platinum, (*in Spanish, little silver*) — In small lamellar grains; colour, between steel and silver; hard as iron, malleable, infusible with intense heat; found along with gold, in mines of Peru and Brazil.

Palladium—In small grains; alloyed with platina.

Iridium, and Osmium—In grains, alloyed with platinum and iridium.

Tellurium — In minute metallic crystals; colour, between tin and lead; variety—graphic; found in Transylvania, in veins of porphyry; yellow and black tellurium.

Mercury, (*quicksilver*) — Native, pure, in metallic globules, fluid; silver white; found in primary rocks; coal formations, amalgamated with silver; semi-fluid; crystallized.

Cinnabar, (*sulphuret of mercury*) — Massive, crystallized; colour, bright carmine red, dark red, grey; varieties — hepatic, bituminous.

Horn quicksilver, (*chloride of mercury*)—In quadrangular pyramidal crystals; colour, grey, yellowish.

Silver, (*native*) — In small crystallized grains; pure white, or tinged grey, probably by sulphur; found with other ores, in the primary and secondary rocks. Amalgamated with gold, antimony, arsenic, molybdena, bismuth and lead.

Sulphuret of silver, (*vitreous*) — In cubical and octohedral crystals; colour, dark lead grey; sometimes iridescent; varieties — black sulphurous, flexible do.; brittle; sulphuret of silver, with antimony.

Red silver — Crystallized, massive, dentritic or arborescent; colour, varies from brilliant dark red, to iron black.

Muriate of silver, (*horn silver*) — Massive, and in small cubical crystals; colour, pearl grey, greenish red.

Carbonate of silver — Massive, soft; colour, grey, black.

Copper, (*native*) — In cubical and octohedral crystals, arborescent, massive; found in primary rocks.

Sulphuret of copper, (*vitreous*)—In six sided prisms, and obtuse pyramids; colour, grey, black.

Copper pyrites—In tetrahedral crystals, stalactites, botryoidal; colour, bright yellow; iridescent.

Tennantite — In rhombic dodecahedrons; colour, lead grey.

Red oxide of copper—In octohedral crystals; colour, red; iridescent; varieties—ferruginous or tile ore, black oxide, hydrate.

Blue carbonate of copper—Variously crystallized, lamellar; colour, deep blue.

Green carbonate of copper, (*malachite*) — In slender fibres, silky, brittle; colour, green; varieties — anhydrous, carbonate, chrysocolla.

Sulphate of copper, (*blue vitriol*)—In powder and stalactites, rarely crystallized in nature; colour, deep blue.

Muriate of copper—In minute crystals; green.

Phosphate of copper—Crystallized; radiated masses; green.

Arseniate of copper—In octohedral crystals; colour, sky blue, green.

Iron, (*native*) — In thin cellular plates, malleable, flexible, magnetic; colour, light steel grey; found in primary rocks, rare; in volcanic lava; in meteoric stones combined with nickel.

Iron pyrites, (*sulphuret*)—In cubical and octohedral crystals, massive, globular; colour, brass yellow; disseminated in various rocks, slates, &c.: varieties—radiated, hepatic, arsenical, auriferous, seleniferous, white; magnetic, yellowish white.

Oxydulated iron—Earthy, compact, in octohedral crystals; colour, iron black; shining lustre, very abundant in beds in various rocks; used for smelting, to form cast and malleable iron.

Specular iron—Lamellar, in rhom-

boidal crystals; colour, deep steel grey; brilliant, sometimes iridescent; varieties—volcanic, micaceous.

Hydrate of iron—Massive, crystallized, fibrous; colour, black, shining.

Red iron ore, (*hematite*)—Fibrous, radiating, in round masses; colour, grey, with slight metallic lustre; abundant, used for smelting; varieties—fibrous, compact, scaly, red ochre, red chalk.

Brown iron ore—Crystallized; dark brown; varieties—fibrous brown, compact, ochery, umber.

Black iron ore—In masses, kidney shaped; colour, dark brown; contains manganese.

Bog iron ore—In friable porous masses, found in morasses, a recent formation.

Clay iron stone—In flat masses; ash grey; found in coal measures.

Chromate of iron—Massive, hard; black; found in serpentine rocks, used as a yellow paint.

Sulphate of iron, (*green vitriol*)—In powder and stalactites; colour, green.

Grey oxide of manganese—In prismatic crystals, massive, fibrous; colour, steel grey; frequent in iron mines; varieties—foliated, radiated, fibrous, compact, earthy.

Sulphuret—Massive; dark brown metallic lustre.

Uranium—Occurs as an oxide and phosphate, the latter a quadrangular prism; colour, yellow, green, brownish; found in granite rocks.

Cerium—Forming a fluate with the fluoric acid, crystalline; colour, yellow; rare.

Tantalum—In rhombic prisms; black, internal lustre.

Cobalt—Occurs as a sulphuret, granular; yellow, steel grey; earthy, of various shades of yellow and red, in masses; oxide, black, brown, yellow.

Nickel, (*native*)—In capillary filaments; colour, yellow, steel grey; combined with copper, arsenic.

Molybdenum, (*sulphuret*)—Massive, lamellar, flat hexahedral tables; colour, like newly cut lead; oxide of various shades of yellow.

Tin oxide—In quadrangular prismatic crystals, lining the sides of cavities in veins; colourless, transparent, or yellowish; found in veins and beds in primary rocks, abundant in Cornwall; varieties—crystallized, granular, fibrous.

Tin pyrites, (*sulphuret*)—Massive; steel grey, yellowish.

Titanium—In very small octohedral crystals; colour yellowish.

Zinc blende, (*sulphuret of zinc*)—Massive, and crystallized in various forms, the primary, the rhombic dodecahedron; colour, brown, yellow, reddish; lamellar.

Red oxide of zinc—Massive, lamellar; various shades of red.

Carbonate of zinc, (*calamine*)—Crystallized, earthy; colour, grey, yellow, brown.

Sulphate of zinc, (*white vitriol*)—Massive, stalactitic; colour, yellowish.

Bismuth—Massive, opaque, friable; colour, green, and yellowish grey.

Lead, (*native*)—In small masses; found in lava.

Galena, (*sulphuret*)—In cubical and octohedral crystals, metallic lustre; found abundantly in beds and veins, chiefly in limestone rocks; varieties—compact, specular, foliated, antimonial, sulphuret, argentiferous, triple sulphuret, blue lead.

Oxide of lead—In powder; scarlet, yellow.

Carbonate, *phosphate*, *chromate*, *arseniate*, *sulphate*—All these salts of lead are crystallized; of various colours, white, yellow, greenish.

Chromate of lead—Massive, crystallized; colour, deep orange.

Antimony, (*native*)—In kidney-shaped masses, lamellar; colour, tin white.

Grey antimony, (*sulphuret*)—Massive, crystallized in rhombic prisms; colour, light lead grey; varieties—acicular, with indistinct crystals radiating from a centre, plumose, compact.

Red antimony—In fine acicular crystals; colour, bright red.

White antimony, (*oxide*)—In tabular and acicular crystals; colour, white, yellowish; ant. ochre, soft, brittle, yellow.

Arsenic, (*native*)—In masses; colour, dull grey, lead grey, white.

Oxide of arsenic—Earthy; colour, snow white.

Sulphuret of arsenic—Massive, acicular crystals; colour, brilliant red.

Orpiment—Massive, in powder; colour, bright lemon yellow.

INFLAMMABLE MINERALS.

Sulphur—Massive, in minute powder, and crystallized in the form of acute octohedrons, variously modified; colour, yellow; burns with a blue flame; found in veins and beds in primary rocks; in volcanoes, and combined with metallic ores, forming sulphurets.

Diamond—In detached crystals of various forms; colourless, or slightly tinged; the hardest substance in nature, and when polished refracting the different colours with exceeding brilliancy; composed of pure carbon; highly inflammable; found in Golconda and Brazil among diluvial soil, mingled with gritstone rocks, and quartzose pebbles; supposed to owe its origin to vegetable matter. The pit or regent diamond, one of the crown jewels of France, weighs 136 carats, or nearly 1 oz. A diamond, in the possession of Catherine of Russia, weighed 193 carats, or 1¼ oz. One belonging to the Raja of Borneo, of exquisite brilliancy, weighs 367 carats, or upwards of 2 oz.

Anthracite, (*blind coal*)—Of a dull iron black colour; light, brittle, burns without flame.

Plumbago, (*black lead*)—In lamellar masses, and kidney shaped nodules, rarely crystallized; colour, steel grey, glistening metallic lustre, streak lead coloured, composed of carbon and iron; found in primary rocks; that in Borrodale, in Cumberland, is used for manufacturing lead pencils.

Bitumen—Of a dark brown colour; peculiar odour, burns with a bright flame; varieties—elastic bitumen; compact or asphaltum; earthy.

Jet coal—In masses, hard, susceptible of polish; colour, velvet black; a petrified wood.

Amber—In nodules, or roundish masses; waxen lustre; colour, yellow, reddish; found enveloping insects and leaves; of vegetable origin.

SECTION XVIII.

DIRECTIONS FOR THE PRACTICAL GEOLOGIST.

As an accurate knowledge of geology can only be acquired by the study of rocks and strata in their natural positions, the student should avail himself of every opportunity of making observations for himself. In his excursions, few implements are necessary: a hammer sufficiently large to break off a fragment of rock, and formed of an oblong or oval shape, as concentrating power within the smallest focus, weighing from one to three pounds; a smaller chipping hammer, of a wedge-like form; a strong bag of moleskin cloth, with a strap to suspend it over the shoulder; a small pocket compass, and a thermometer, if journeys are to be long extended, are requisite; a note book is also necessary, as minute circumstances, and especially sketches and sections, should never be trusted to memory. In selecting geological specimens, they should be taken fresh from the masses of rock. The most convenient size is from four to five inches long, by three inches broad, and they should be shaped by the chipping hammer into oblong parallelograms. Of many rocks, however, specimens of one or two inches square will be quite sufficient to indicate their character; and this size, where weight and bulk is a matter of consideration, will be found most convenient. All specimens, especially crystallized minerals, should be rolled in paper, so as to prevent friction on their surfaces. In arranging them after returning from the field, their localities and positions in the strata should be carefully noted.

In the investigation of a country, natural and artificial sections of the rocks, as cliffs, pits, and quarries, should be first visited. If strata present themselves, the general direction of these strata should first be ascertained, and then the dip or inclination. Thus a ledge of stratified rocks may have a general direction west and east, although the dip of the strata may be south or north. If the strata consist of layers of one or more different rocks, these are to be measured and noted according to the order of position. The diluvial gravel above

is next to be examined — the boulders or transported stones — the alluvial or more recent deposits—and, lastly, the vegetable soil. Then follows an examination of the valleys, springs, wells, and river courses, if any — the mountains, their height and form, and other remarkable appearances which they may present.

MEASUREMENT OF HEIGHTS BY THE BAROMETER.

As the pressure of the atmosphere diminishes in a regular ratio, corresponding to the elevation above the earth's surface, the barometer has been employed for indicating this diminution, and consequently for ascertaining the heights of mountains. Thus, for every hundred feet of ascent, the barometer, in round numbers, falls about one-tenth of an inch ; so that if, at the foot of a mountain, this instrument stands at 30 inches, while, at the top, it falls to 27 inches, we conclude that the mountain is three thousand feet in altitude. This general indication would be exact, were it not for the variation of temperature, and some other accompanying circumstances, which are specified in the following formula.

DIRECTIONS FOR USING ENGLEFIELD AND NIXON'S PORTABLE BAROMETERS.

Note down the height of barometer at lowest station, in inches, tenths, hundredths, and thousandths.

Note also the degree of attached and detached thermometers.

Repeat these observations and notanda, at the summit or highest station.

Take the mean and difference of the barometer, the difference of the attached thermometer, and the sum of the detached.

Correct for difference of attached thermometer, by multiplying that difference by one ten-thousandth of the mean barometric pressure. The product is to be subtracted from the barometric difference (marked on the barometer,) when the upper station is colder, and added to it when warmer.

Correct for the temperature of the air above zero of Fahrenheit, as follows: — Consider the sum of the detached thermometer as thousandths, add to it the integer 1,000, multiply together this sum, the corrected barometric difference, and the constant number 24,900, divide the product by the mean barometric pressure, the quotient is the height in English feet, nearly thus: —

Lower station, bar. press.	30.040	Attach. ther.	72.5	Detach. ther.	72.0
Upper station,	26.575		63.5		62.6
Mean,	28.307	Diff.	9	Sum,	134.6
Difference,	3.465				

Correction for diff. of att. therm. $9 \times .00283 = .0254$ & $3.4650 - .0254 = 3.4396$

Sum of detach. therm. $+ 1.000 = 1.1346 \quad \frac{1.1346 \times 3.4396 \times 24900}{28.307} = 3433.7$ feet.

The *Sympiesometer*, an instrument more portable than the barometer, indicates heights by the pressure of the atmosphere, on a portion of hydrogen gas included in a tube, within a column of oily fluid, and for ordinary purposes may perhaps be found sufficiently accurate.

The *Clinometer* is a pocket instrument for ascertaining the line of stratification and dip with accuracy, and is usually accompanied with a magnetic compass.

LIST OF WORKS ON GEOLOGY.

Dr M'Culloch's Classification of Rocks, 8vo.
———— Western Islands, 3 vols. 4to.
Messrs Connybeare and Phillip's Geology of England and Wales, 8vo.
Professor Jameson's Mineralogy and Geology.
Mr Bakewell's Introduction to Geology, 4th edit. 8vo.
M. de la Beche's Manual of Geology, 8vo.
Mr Lyell's Principles of Geology, 4 vols. 12mo. 4th edit.
Dr Thomson's Outlines of Mineralogy, Geology, and Mineral Analysis, 2 vols. 8vo.
Mr Phillip's Guide to Geology, 12mo.
Dr Buckland's Geology and Reliquiæ Diluvianæ.
Baron Cuvier's Recherches sur les Ossmens Fossils, 5 vols. 4to.
Professor Playfair's Illustrations of the Huttonian Theory, 8vo.
William's Mineral Kingdom, 8vo.
Dr Daubeny on Volcanoes.
Von Buch on Volcanoes—Geological Travels, &c.
Dr Boue Geologie de l' Ecosse.
Daubuisson Traitè de Geognosie.
Mr Sowerby's Mineral Conchology, plates.
M. Agassiz Histoire des Poissons Fossiles, fol. plates.
Woodward's Natural History of Fossils, plates.
Parkinson's Organic Remains, 3 vols. 4to. plates.
Goldfuss Petrefacten Kunden, folio, plates.
Brogniart Histoire des Vegetaux Fossiles, 4to. plates.
Sternberg Flora der Vorwelt, fol. plates.
Messrs Lindly and Hutton's Fossil Flora, 8vo. in numbers, plates.
Miller's Crinoidea, 4to. plates.
Murchison and Sedgwick, numerous papers in London Geological Transactions.
Hibbert, in Edinburgh Philosophical Transactions.
Dr Mantell on Geology of the Wealds of Sussex, 8vo.
Mr Phillip's Geology of Yorkshire, 8vo.
Rhind's Geology of Environs of Edinburgh.
Silliman's American Journal.
Smith's large Geological Map of England.
M'Culloch's Geological Map of Scotland and its Islands.
Griffith's Reports of the Geology of Ireland.
M'Greenough's small Map of England.
Von Buch's Map of part of Europe, Berlin.

WORKS ON MINERALOGY.

Phillips' Mineralogy, 8vo.
Jameson's Mineralogy, 8vo.
Allan's System of Mineralogy, 8vo.
Conversations on Mineralogy, by Mr and Miss Lowry, 2 vols. 12mo.

GLOSSARY.

Aggregate—A solid mass of matter of the same or different kinds of substances joined together.

Alluvium—Earth, clay, sand, gravel, and stones, transported by currents, and deposited on the surface of strata. Diluvium has much the same signification.

Ammonite—An extinct molluscous animal allied to the modern nautilus, inhabiting a chambered shell, so called from its resemblance to the horns on the statues of Jupiter Ammon.

Amorphous—Bodies devoid of regular form, in contradistinction to crystallized bodies, &c.

Amygdaloid—A form of trap rock where lime and quartz appear imbedded like almonds in a cake.

Anoplotherium—an extinct quadruped of the order Pachydermata—from ανοπλος, unarmed, and θηριον, a wild beast.

Argillaceous—Clayey.

Attrition — A wearing down, or grinding into minute particles.

Augite—A simple mineral of a dark green or black colour.

Basalt—A trap rock, dark green or black, composed of augite and felspar.

Belemnite—An extinct molluscous animal, having a long straight chambered conical shell—from βελεμνον, a dart.

Bituminous Shale — A clayey slate, containing bitumen or pitch.

Bivalve—A shell with two valves.

Boulder Stones—Round blocks of detached stone found on the surface, or imbedded in the soil, and which have been transported from a distance by currents of water.

Breccia—A rock composed of angular fragments connected together by some cementing earths—from the Italian.

Calc, or *Calcareous Spar*—Carbonate of lime crystallized.

Carbon—Charcoal, a simple inflammable substance—from *carbo*, coal.

Carboniferous — Strata containing coal, from *carbon* charcoal.

Cetacea——The whale tribe.

Chert—A mixture of siliceous matter and limestone.

Claystone — A trap rock composed chiefly of clay.

Clinkstone, called also *Phonolite*—A trap rock, chiefly felspar.

Coal Formation, or *Coal Measures*—Terms applied to the strata containing seams of coal.

Columnar— Shaped like pillars or columns.

Comminuted — Worn down into minute particles.

Conchoidal — Hollow like a shell; applied to the fractured surfaces of rocks.

Conformable —When the planes of one set of strata are parallel to another, they are said to be conformable; but when the reverse, *unconformable.*

Conglomerate — A mass of rounded pebbles cemented together.

Coniferæ — Plants which, like the fir, bear cones.

Coprolites—Nodules containing the fæces of fish or reptiles.

Cosmogony — Speculations respecting the first origin or mode of creation of the world.

Crater — The circular mouth of a volcano.

Crop out—The rising up of strata to the surface.

Crustacea — Animals of the crab kind.

Cryptogamic—Plants, such as ferns, mosses, where there are no conspicuous flowers.

Debris—The mouldering fragments of rocks.

Denudation—The carrying away of the upper strata by the action of running water, by which the rocks below are laid bare.

Deposition, *Deposited*— Applied to sedimentary materials suspended in water which have afterwards settled down and formed solid strata.

Dicotyledonous—Plants having two seed lobes, as the bean.

Dikes—Large veins of granite, or trap rocks, running through stratified rocks.

Diluvium—An accumulation of clay and debris of rocks of an earlier date than alluvium.

Dip—The inclination of a stratum from its perpendicular or horizontal position.

Disruption—A breaking through, or asunder.

Disintegrate—To grind down.

Dolomite—A crystalline magnesian limestone—called after the geologist Dolomieu.

Estuary—An arm of the sea, into which a river flows.

Extinct Animals — Beings that no longer exist as species on the earth; applied also to plants.

Fault—The sudden interruption of a stratum, by one end slipping below the other, or the intrusion of a vein or dike.
Felspar—Alumina or clay, an ingredient in granite and trap.
Formation—A group of rocks or strata of one age or period of production.
Fossils—The remains of animals or plants more or less converted into stone, as found in the rocks or soil.
Geology—From γεα, the earth, and λογος, a discourse.
Greenstone—A trap rock composed of felspar and hornblende.
Greywacke—From *grau*, grey, and *wake*, a German provincial term. The lowest series of secondary rocks.
Grit—Coarse grained sandstone.
Gypsum—Sulphate of lime, plaster of Paris.
Habitat—The natural abode of an animal or plant.
Hornblende—A simple mineral of a dark green or black colour—an ingredient of trap rocks.
Hypersthene—From υπερ, above, and σθενο, strength; a rock of the hornblende family, very hard and dark-coloured.
Ichthyosaurus—A gigantic fossil reptile—from ιχθυς, a fish, and σαυρα, a lizard.
Lacustrine—From *lacus*, belonging to a lake.
Laminar—Disposed in thin leaves or layers.
Lias—A provincial name for a clayey limestone.
Littoral—From *littus*, belonging to the shore.
Locality—This term is applied to the place where any mineral or plant, or animal, is found naturally to exist. In Geology, to the districts or regions of the globe where particular formations of rocks occur, or to rocks containing particular minerals.
Lycopodiaceæ—Plants, intermediate between ferns and the coniferæ. The fossil ones being of gigantic size.
Madrepore—Corals with star-shaped cavities.
Mammoth—A fossil elephant—from a Tartar word signifying to burrow under ground.
Mastodon—A genus of fossil elephant with conical grinding teeth—from μαστος, pap, and οδιον, tooth.
Matrix—The mass in which a mineral or fossil is fixed or embedded—from *matrix*, a womb.
Mechanical origin—Rocks composed of particles that have been suspended in water not chemically dissolved.
Megalosaurus—A fossil lizard—from μεγαλη, great, and σαυρα, lizard.
Megatherium—A fossil quadruped like the sloth—from μεγα, great, and θεριον, wild beast.
Mica—A simple mineral, having a glittering silvery surface, an ingredient of granite.
Mollusca—A division of the animal kingdom—those animals having a soft fleshy body, with no bones, as the oyster, snail.
Monocotyledonous—Plants with one seed lobe, as common wheat, palms, &c.
Muschel kalk—A limestone found in Germany—shell-limestone.
Nodule—A round mass or little knot.
Nucleus—A solid centre round which other matters collect.
Obsidian—A kind of lava—volcanic glass.
Olivine—An olive coloured mineral found in lava.
Oolite—An impure limestone formed of round bodies, like the roe of a fish—from ωον, an egg, and λιθος, a stone.
Organic remains—Animals and plants found in the earth's strata, generally converted into stone, bitumen, &c.
Ornithichnites—Impression of birds feet—from ορνις and τυψνος, stoney bird-tracts.
Orthoceratites—Extinct molluscous animals that inhabited a long chambered shell, like a straight horn.
Oxygen—The vital air of the atmosphere which combines with earths, metals, &c., forming oxides.
Pachydermata—An order of animals like the elephant, horse, pig—from παχυς, thick, and δερμα, skin.
Pelagic—Belonging to the deep sea.
Petrifactions—Substances converted into stone—from *petra*, a rock, and *facio*, to make.
Pitchstone—One of the trap rocks—so called from its resemblance to consolidated pitch.
Plesiosaurus—A fossil reptile—from πλησιον, near to, and σαυρα, a lizard.
Plutonic rocks—Those formed by the action of heat; granite, trap, and volcanic rocks are so called, being produced from below in a fused state.
Porphyry—An igneous rock having crystals of felspar or other earths

imbedded in a common base—from πορφυρα, purple.

Precipitation — The separating or throwing down of substances from an aqueous solution.

Producta—An extinct animal with a two-valved shell, found in the older rocks; analogous to the living terebratula.

Pumice—A light spongy lava.

Pyrites—(iron)—a sulphuret of iron.

Quartz — Silex or flint — a simple earth.

Saccharine — From σακχαρ, sugar, ειδος, form.

Sandstone—Any stone composed of minute grains, or particles cemented together, generally applied to stones having the ingredients of granite— viz. felspar, quartz, and mica.

Saurian — Animals of the lizard tribe—from σαυρα, a lizard.

Schist—From *schistus*, that can be split.

Sedimentary rocks — Rocks formed by their particles being thrown down from a suspension in water, and then consolidated.

Soluble—That can be dissolved in a fluid—*insoluble*, the reverse.

Stalactites — Lime which has been deposited from water in the form of icicles hanging from a roof—from σταλαζω, to drop.

Stalagmite—Lime deposited in the same way on the floor of an apartment or cavern.

Stratum—pl. strata. When several rocks lie like the leaves of a book, one upon another, each individual forms a stratum.

Subordinate—Applied to strata that are inferior in position, and inferior in extent or thickness to the principal beds of the same formation.

Syenite—A kind of granite containing hornblende.

Trachyte — A kind of porphyritic lava with a rough surface—from τραχυς, rough.

Trap — A general term for plutonic rocks, composed of felspar, aguite, hornblende, and sometimes quartz. For the different species see table, p. 124.

Thermal springs—Hot springs.

Tuff or *Tuffa*—A soft earthy rock of the trap family or the scoriæ of modern volcanoes.

Univalve—Shells with one valve.

Vesicular—Formed into bladders or blisters—from *vesica*, a blister.

Wacke — A soft earthy variety of basalt.

Zoophites — Corals, sponges, and other plant-like animals.

QUESTIONS.

Section I.

1. What does Geology treat of?

2. How far has man penetrated into the earth?

3. What is the supposed density of the solid mass of the globe?

4. Is the external form of the earth a sphere?

5. What is the general form of the earth's surface?

What proportion does the land bear to the water?

6. What is the height of the atmosphere surrounding the earth?

Section II.

7. What simple substances enter chiefly into the composition of the earth's strata?

8. What is the condition of those substances as we find them combined to form rocks?

9. What is the nature of silica or quartz?

10. Is silica easily fused or dissolved in acids?

11. What rocks and gems contain silica?

What is glass composed of?

12. What sort of earth is alumina or clay?

13. What rocks chiefly consist of alumina?

14. What is felspar? and what is it chiefly used for?

15. What gems are formed of alumina?

16. What is the nature of lime?

What takes place when carbonate of lime is subjected to heat?

17. How is limestone distinguished from quartz?

18. Does lime exist in animal and vegetable bodies?

19. What is magnesia?

20. Enumerate the other earths less frequently found in rocks?

21. What is the nature of potassa and soda?

What is their simplest form?

22. What is mica?

23. What is hornblende?

Section III.

24. What is the general arrangement of the substances forming the crust of the earth?

25. Whence arises the distinction of primary and secondary rocks?

26. What is the meaning of strata and stratification?

27. What is the difference between unstratified and stratified rocks?
28. How are the strata variously inclined?
29. What is the general succession of the rocks as found most usually prevailing on the earth's surface?

SECTION IV.

30. What is the first or lowest rock of the series?
31. What is granite composed of? Are there varieties of granite?
32. What is granite resembling porphyry called?
33. Does granite resemble trap rocks?
34. What minerals are contained in granite?
35. Is granite a common rock?
36. Is granite one of the oldest rocks?
Has there been more recent eruptions of granite?
37. Are some kinds of granite easily acted on by the atmosphere?
What is the result of their decomposition?
38. What appearances do granite mountains assume?
39. In what countries is granite found?
40. Is granite used for architectural purposes?

SECTION V.

41. What are trap or greenstone rocks composed of?
How have these rocks been formed?
42. How are the trap rocks ascertained to be of more recent origin than the secondary strata?
43. What are the characteristics of greenstone?
44. What sort of rock is claystone?
45. What is wacke?
46. What is the nature of clinkstone?
47. What is compact felspar?
48. What is basalt?
Where is Fingal's Cave, and of what is it formed?
49. What has given rise to the structure of amygdaloid rock?
Why is it called amygdaloid, and what is it called in Derbyshire?
50. What does pitchstone resemble?
51. What is serpentine?
52. What is the appearance of diallage?
53. What constitutes porphyry?
Where is it found?
54. Do trap rocks easily wear down by the action of the atmosphere?
What chain of trap rocks intersects Scotland.
55. What is the nature of Volcanic rocks?

SECTION VI.

56. What is the composition of gneiss?
57. What is its usual position?
Is it stratified?
58. What are the varieties of gneiss?
59. What metals are found in gneiss?
60. Are any organic remains found in gneiss?
61. What is the composition of mica slate?
62. What is its position? and is it found in various parts of the world?
63. What is chlorite slate?
64. What is talcose slate?
65. What is hornblende slate?
66. What is quartz rock?
67. What are its varieties and position with regard to other rocks?
68. What is the composition of argillaceous slate?
What minerals are found in it?
69. What are slates used for?
70. What characterizes primary limestone?
71. What is chert?
72. Is lime more frequent in the primary or secondary strata?

SECTION VII.

73. What characterizes the rocks of the secondary class?
What is the nature of petrifactions?
Whence is the word derived?
74. What is greywacke, and whence is the name derived?
75. What is the trilobite?
Is greywacke a common rock, and what are its localities?
76. What distinguishes the old red sandstone?
From what rocks has it probably been formed?
77. What is the position of the carboniferous limestone?
78. What are the most common organic remains in the mountain limestone?
79. Does it ever exhibit traces of fresh water origin?
80. What is the process of forming common lime for mortar?
What metals are found in the mountain limestone?
81. What is the composition of the carboniferous sandstone strata?
What is the general form of coal fields?
From what rocks has the carboniferous sandstone been formed?
82. What is the origin of coal, and what are the proofs of this origin?
How has it been deposited?
What is the meaning of faults or slips in the coal strata?
83. What is the nature of the ve-

getables which form coal? and enumerate the most common.

84. What is the general thickness of coal seams?

How are they wrought?

What gas escapes from coal, and how is its inflammability prevented?

85. What countries produce coal in greatest abundance?

What is the annual produce of the British coal mines?

What providential arrangements are exemplified in the natural formation of coal?

86. What is the position of the new red sandstone?

87. What is the position of magnesian limestone?

What is the German rock called which corresponds to the English magnesian limestone?

What lies above the magnesian limestone?

88. What is muriate of soda, and in what strata is it found?

What counties in Britain contain rock salt?

Describe the salt mines of Spain and of Poland.

89. What animals have left their impressions in the new red sandstone?

90. What is lias, and where is it found in England?

What fossils are characteristic of this formation?

Where has the lias been deposited?

What is the ichthyosaurus, and whence is the name derived?

What is the plesiosaurus, and the derivation of the name?

91. What do the oolite beds derive their name from?

What are the organic remains of the oolite?

What are the subordinate beds into which it is divided?

Where are the chief localities of the oolite?

92. What is the position of the wealden beds?

93. What is the position of chalk, and where is its chief localities?

What is Shakspeare's Cliff composed of?

What is the position of the green sand?

How has chalk been deposited?

What are the most common organic remains of the chalk?

Section VIII.

94. What are the tertiary strata?

95. What is contained in the Paris Basin?

What fossil skeletons are found in it?

Who first discovered these skeletons?

Describe the paleotherium.

Describe the anoplotherium.

96. What was the mammoth?

What distinguishes the mastodon from the mammoth?

Where is the mastodon found?

Describe the manner in which the fossil Siberian elephant was discovered

What is peculiar in the skeleton of the megatherium, and what animals is it supposed most nearly to have resembled?

What other animals have been found in the diluvial soil?

97. Describe the bone cave of Yorkshire, and its contents.

98. Have any traces of man been discovered in the earthy strata?

How can we account for the absence of human skeletons among the profusion of those of other animals?

Section IX.

99. What are the changes at present taking place on the earth's surface?

Enumerate the causes of those changes.

100. What are the agencies which counteract this gradual decay?

Explain the nature of the protection afforded by vegetation.

101. Explain the nature of the compensatory powers of animals.

Describe the formation of coral islands.

102. Are the changes on the old world within the records of history, very great or conspicuous?

103. What is the nature and formation of peat?

Give examples of this formation.

Section X.

104. What does diluvium and alluvium mean?

105. What are boulder stones?

What general causes have thus transported them, and enumerate illustrations?

106. What is the meaning of denudation?

Section XI.

107. What is the nature of volcanoes?

108 What is the usual situation of volcanic mountains?

What is the computed number of existing volcanoes, and in what regions of the globe are they found?

What is the nature of a volcanic eruption?

109. What are the varieties of lava?

110. What is the probable cause of volcanic action?

111. Describe Etna and its eruptions.

112. Describe the formation of Graham Island.
113. Describe Vesuvius.
114. Describe Hecla.
What are the Gysers ?
115. What is the nature of an earthquake ?
What is the effect of earthquakes on the surface of the globe ?
116. Are earthquakes mentioned in the early history of the globe ?
Describe the great Lisbon earthquake.
When did the earthquake at Calabria take place ?
117. Is South America subject to earthquakes, and what memorable one occurred there ?
118. Have any earthquakes occurred in England ?
When have they happened in Scotland ?

Section XII.

119. What is meant by temperature ?
120. What is the chief source of heat ?
Does the temperature vary, and what is the medium degree of heat ?
121. Does the temperature vary at different altitudes.
122. What are the different opinions regarding central heat ?
123. What is Mr Lyell's theory of the change of temperature ?

Section XIII.

124. What proportion of the surface of the earth is dry land ?
What is remarkable in the position of this dry land ?
125. Is the dry land always above the ocean level ?
126. What has been the cause of the elevation of mountains ?
127. How does the elevation of mountain ranges affect rivers ?
Which are the most elevated mountains in the world ?
How does the elevation of mountains affect climate, and the habitats of plants and animals ?
What is the highest land in Europe ?
Which is the highest mountain in Britain ?
128. How are valleys caused ?

Section XIV.

129. Is the ocean continuous around the globe ?
Is its level every where the same ?
What causes may influence a difference of level ?
130. What gives the peculiar saltness to the water of the ocean ?
Enumerate the saline substances.
131. What gives rise to currents in the ocean ?

Section XV.

132. What is the source of moisture on the land ?
133. How are clouds characterized ?
134. What is the cause of springs and rivers ?
What are artesian springs, and whence is the name derived ?
135. What are thermal springs ?
136. How are lakes formed ?
137. Which are the largest rivers in the world ?
138. Which are the most remarkable waterfalls ?

Section XVI.

139. How are metals formed ?
What is the usual combination of a metallic ore ?
What is the general direction and thickness of metallic veins ?
Are metals found otherwise than in veins ?
140. How are metallic veins wrought ?
What are the properties of metals ?
What are the names of the principal metals ?
How is gold found and separated from the sand ?
What is platina ?
Where is silver most abundant ?
What is peculiar about mercury ?
Where is copper ore found ?
Is iron an abundant metal ?

THE END.

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